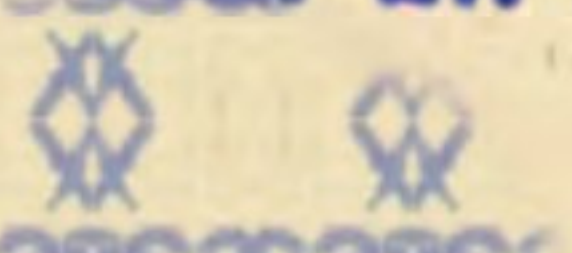


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N E H

N E H

NEHEMIAH, or NEEMIAS, son of Hachaliah, was born at Babylon during the captivity, (Neh. i. 1, 2, &c.) He was, according to some, of the race of the priests, but, according to others, of the tribe of Judah and the royal family. Those who maintain the first opinion, support it by a passage in Ezra, (x. 10.) where he is called a priest; but those who believe that he was of the race of the kings of Judah, say, 1st, That Nehemiah having governed the republic of the Jews for a considerable time, there is great probability he was of that tribe of which the kings always were. 2dly, Nehemiah mentions his brethren Hanani, and some other Jews, who coming to Babylon during the captivity, acquainted him with the sad condition of their country. 3dly, The office of cup-bearer to the king of Persia, to which Nehemiah was promoted, is a further proof that he was of an illustrious family. 4thly, He excuses himself from entering into the inner part of the temple, probably because he was only a laic, (Neh. vi. 11.) "Should such a man as I flee? And who is there that, being as I am, would go into the temple to save his life?"

The scripture (Ezra. ii. 62. Nehem. vii. 95.) calls him *תרשבת* *tirshatha*, that is to say, "cup-bearer;" for he had this employment at the court of Artaxerxes Longimanus. He had an exceeding great tenderness for the country of his fathers, though he had never seen it; and one day as some Jews newly come from Jerusalem acquainted him with the miserable estate of that city, that its walls were beat down, its gates burnt, and the Jews were become a reproach among all nations; he was sensibly affected with this relation; he fasted, prayed, and humbled himself before the Lord, that he would be favourable to the design he had then conceived of asking the king's permission to rebuild Jerusalem. The course of his attendance at court being come, he presented the cup to the king according to custom; but with a countenance sad and dejected; which the king observing, entertained some suspicion, as if he might have had some bad design; but Nehemiah (ii.) discovering the occasion of his disquiet, Artaxerxes gave him leave to go to Jerusalem, and repair its walls and gates: but, however, upon this condition, that he should return to court at a time appointed. Letters were made out, directed to the governors beyond the Euphrates, with orders to furnish Nehemiah with timbers necessary for covering the towers and gates of the city, and the house designed for Nehemiah himself, who was now appointed governor of Judea, in the year of the world 3350.

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Nehemiah being arrived at Jerusalem with the king's commission, went round the city; and having viewed the condition of the walls, assembled the chief of the people, produced his commission, and exhorted them to undertake the reparation of the gates and walls of the city. He found every person ready to obey him; whereupon he immediately began the work. The enemies of the Jews, observing these works in such forwardness, made use of all the means in their power to deter Nehemiah from this undertaking, and made several attempts to surprise him; but finding that their designs were discovered, and that the Jews kept upon their guard, they had recourse to craft and stratagem, endeavouring to draw him into an ambuscade in the fields, where they pretended they would finish the dispute at an amicable conference: but Nehemiah gave them to understand, that the work he had begun required his personal attendance; and therefore he could not come to them. He sent the same answer to four several messages that they sent one after another on the same subject, (*id.* iv. and vi.)

Sanballat, the chief of the enemies of the Jews, together with his associates, wrote word, that a report was spread that the Jews were building the walls of Jerusalem only with a design to make it a place of strength, to support them in an intended revolt; that it was said also that Nehemiah had suborned false prophets to favour his designs, and to encourage the people to choose him king; and to stop the course of these rumours, he advised him to come to him, that they might confer together, and take such resolutions as should be found convenient. Nehemiah gave himself no trouble on this account, but returned for answer, that all those accusations were false and made at random. About the same time he discovered, that a false prophet, called *Shemaiah*, had been corrupted by his enemies, and that some of the chief of the city were secretly in confederacy with them. Yet all this did not discourage him: he went on with his work, and happily completed it in two and fifty days after it had been begun.

Then he made a dedication of the walls, of the towers, and of the gates of Jerusalem, with the solemnity and magnificence that such a work required. He separated the priests, the Levites, and the princes of the people, into two companies, one of which walked to the south and the other to the north, on the top of the walls. These two companies were to meet at the temple. The procession was accompanied with music both vocal and instrumental: and when they were all come to the temple, they there read the law,

A offered

Gmc 515

Nehemiah. offered sacrifices, and made great rejoicings. And as the feast of the tabernacle happened at the same time, it was celebrated with great solemnity, (*id.* viii.) Nehemiah observing that the compass of the city was too large for its inhabitants, he ordered that the chief of the nation should fix their dwelling in the city; and caused them to draw lots, by which a tenth part of the whole people of Judah were to dwell at Jerusalem, (*id.* xi.) Then he applied himself to the reformation of such abuses as had crept into the administration of the public affairs. He curbed the inhumanity of the great ones, who held in a state of slavery the sons and daughters of those that were poor or unfortunate, keeping their lands in possession, which these poor people had been obliged either to mortgage or to sell to the rich. Another abuse there was, which Ezra had in vain attempted to redress, that they had contracted marriages with strange and idolatrous women. Nehemiah undertook to dissolve these marriages, succeeded in it, and sent away all such women as had been taken against the express command of the law, (*id.* ix.) Having likewise observed, that the priests and Levites were obliged to take refuge wherever they could, and so the ministry of the temple was not attended or performed with that decency it ought, because they did not receive the revenues that the law had appointed for their subsistence; he obliged the people punctually to pay the ministers of the Lord what was due to them, and enjoined the priests and Levites duly to attend on their respective duties, and to discharge their functions, (*id.* xiii. 10, 11. &c.) He enforced the observation of the sabbath, which had been much neglected at Jerusalem, and would not permit strangers to come in to buy and sell, but kept the gates of the city shut all that day. And, to perpetuate as much as was possible these good regulations which he had newly established, he engaged the chief men of the nation solemnly to renew the covenant with the Lord. This ceremony was performed in the temple, and an instrument was drawn up, which was signed by the principal men, both priests and people, (*id.* ix. x.) in the year of the world 3551.

We read in the books of Maccabees, (2 Macc. i. 19, 20, 21, &c.) that Nehemiah sent to search for the holy fire, which before the captivity of Babylon the priests had hid in a dry and deep pit; but not finding any fire there, but instead thereof a thick and muddy water, he sprinkled this upon the altar; whereupon the wood which had been sprinkled with this water took fire presently as soon as the sun began to appear. Which miracle coming to the knowledge of the king of Persia, he caused the place to be encompassed with walls where the fire had been hid, and granted great favours and privileges to the priests. It is recorded in the same books, (2 Macc. ii. 13, 14) that Nehemiah erected a library, wherein he placed whatever he could find, either of the books of the prophets, of David, and of such princes as had made presents to the temple. Lastly, he returned to Babylon (*id.* v. 14. and xiii. 6,) according to the promise he had made to king Artaxerxes, about the thirty-second year of this prince, in the year 3563. From thence he returned again to Jerusalem, where he died in peace, about the year 3580, having governed the people of Judah for about thirty years.

The book which in the English bible, as also in the Hebrew, has the name of *Nehemiah*, in the Latin bible is called the book of *Esdra*; and it must be confessed, that though this author speaks in the first person, and though at first reading one would think that he had writ it day by day as the transactions occurred, yet there are some things in this book which could not have been written by Nehemiah himself; for example, memorials are quoted wherein were registered the names of the priests in the time of Jonathan the son of Eliahshib, and even to the times of the high priest Jaddus, who met Alexander the Great. These therefore must have been added afterwards.

It may well be questioned, whether this Nehemiah be the same that is mentioned in Ezra, (ii. 2. and Neh. vii. 7.) as one that returned from the Babylonish captivity under Zerubbabel; since from the first year of Cyrus to the twentieth of Artaxerxes Longimanus, there are no less than ninety-two years intervening; so that Nehemiah must at this time have been a very old man, upon the lowest computation an hundred, consequently utterly incapable of being the king's cup-bearer, of taking a journey from Susa to Jerusalem, and of behaving there with all the courage and activity that is recorded of him. Upon this presumption, therefore, we may conclude that this was a different person, though of the same name, and that Tirshatha (the other name by which he is called, Ezra ii. 63, and Neh. vii. 65.) denotes the title of his office, and both in the Persian and Chaldean tongues was the general name given to the king's deputies and governors.

NEHOW, one of the Sandwich Islands, discovered by Captain Cook in his last voyage to the Pacific Ocean: they are eleven in number, and are situated from 18° 44' to 22° 15' N. Lat. and from 154° 56' to 160° 24' W. Long. They are not very particularly described in any account that has hitherto appeared.

NEIGHBOUR, 1. One who dwells or is seated near to another (2 Kings iv. 3.) 2. Every man to whom we have an opportunity of doing good (Matt. xxii. 39.) 3. A fellow-labourer of one and the same people (Act. vii. 27.) 4. A friend (Job. xvi. 21.) At the time of our Saviour, the Pharisees had restrained the word neighbour to signify those of their own nation only, or their own friends; being of opinion that to hate their enemy was not forbidden by their law. But our Saviour informed them, that the whole world were their neighbours; that they ought not to do to another what they would not have done to themselves; and that this charity ought to be extended even to their enemies (Matt. v. 43. Luke x. 29, &c.)

NEISSE, a handsome town of Silesia in Germany; and the residence of the bishop of Breslaw, who has a magnificent palace here. The air is very wholesome, and provisions are cheap; the inhabitants carry on a great trade in wine and linen. This place suffered greatly by an inundation and fire in 1729. It was taken by the Prussians in 1741, who augmented the fortifications after the peace in 1742, and built a citadel to which they gave the name of *Prussia*. It is seated on a river of the same name, in E. Long. 17.35. N. Lat. 50.32.

NEIUS MONS (anc. geog.), at the foot of which stood Ithaca, a town of the island of that name, (Homer).

Nelson.

Nelson.

NELSON (Robert), a learned and pious English gentleman, was the son of Mr John Nelson a considerable Turkey merchant, and was born in June 1656. He had the first part of his education at St Paul's school, London; but the principal part was under a private tutor in his mother's house, after which he studied at Trinity College, Cambridge. In 1680 he was chosen a fellow of the Royal Society; being probably inclined to receive that honour out of respect to his friend and school-fellow Dr Edmund Halley, for whom he had a particular regard, and in whose company he set out in his travels abroad the December following. In the road to Paris, they saw the remarkable comet which gave rise to the cometical astronomy by Sir Isaac Newton; and our author, apparently by the advantage of his fellow-traveller's instructions, sent a description of it to Dr, afterwards Archbishop, Tillotson, by whom he was very much esteemed. Before he left Paris, he received a letter from a friend in the English court, inviting him to purchase a place there, by the promise of his assistance in it. This proposal was made by Mr Henry Saville, brother to Lord Halifax: he had been sworn vice-chamberlain of the king's household in December 1680, and was at this time envoy from Charles II. to the court of France; though now at London, whence he sent this offer in a letter to Mr Nelson; who being but young, and having a great affection for King Charles and the duke of York, was pleased with the thoughts of figuring it near their persons; but as he could not resolve upon an affair of such consequence without the approbation of his mother and uncle, he first applied to Tillotson to sound them, with assurances of determining himself by their judgment and advice, including also that of the Dean; who finding them both averse to it, he thereupon dropped the matter, and pursued his journey with his fellow-traveller to Rome. Here he fell into the acquaintance of Lady Theophila Lucy, widow of Sir Kingsmill Lucy of Broxburne in Hertfordshire, bart. and second daughter of George earl of Berkeley, who soon discovered a strong passion for him: this concluded in marriage, after his arrival in England in 1682. But it was some time before she confessed to Mr Nelson the change of her religion; which was owing to her acquaintance with Bossuet and conversations at Rome with Cardinal Philip Howard, who was grandson of the earl of Arundel, the collector of the Arundelian marbles, &c. and had been raised to the purple by Pope Clement X. in May 1675. Nor was this important alteration of her religious sentiments confined to her own mind, but involved in it her daughter by her first husband, whom she drew over to her new religion; and her zeal for it prompted her even to engage in the public controversy then depending. She is the supposed authoress of a piece written in 1686, 4to, under the title of, "A discourse concerning a judge of controversy in matters of religion, showing the necessity of such a judge."

This misfortune touched her husband very nearly. He employed not only his own pen, but those of his friends Dr Tillotson and Dr Hickes, to recover her: but all proved ineffectual; and she continued in the communion of the church of Rome till her death. She was a person of fine sense and understanding. Dr

Tillotson particularly laments her case on that account; and even seems not to be entirely free from all apprehensions of the influence she might have upon her husband in this important affair. But Mr Nelson's religion was too much the result of his learning and reason to be shaken by his love, which was equally steady and inviolable. Her change of religion made no change in his affections for her; and when she relapsed into such a bad state of health as obliged her to go and drink the waters at Aix, he attended her thither in 1688: and not liking the prospect of the public affairs at home, he proceeded to make a second trip to Italy, taking his lady, together with her son and daughter by her former husband, along with him. He returned through Germany to the Hague, where he staid some time with Lord Dursley, who was married to his wife's sister.

From the Hague he arrived in England, in the latter end of 1691; where being averse to the Revolution, he declared himself a nonjuror, and left the communion of the church of England. In this last point he had consulted Dr Tillotson, and followed his opinion, who thought it no better than a trick, (detestable in any thing, and especially in religion), to join in prayers where there was any petition which was held to be sinful. Thus, notwithstanding their difference of opinion respecting the lawfulness of the revolution, the friendship between them remained the same; and the good archbishop expired in his friend's arms in 1694. Nor did Mr Nelson's friendship end there: he continued it to his grace's widow, and was very instrumental in procuring her pension from the crown to be augmented from 400*l.* to 600*l. per annum.* It is very remarkable, that the great regard he had always shown to Tillotson, added to his own reputation for learning, judgment, and candour, induced Dr Barker, who published the archbishop's posthumous sermons, to consult our author on that occasion. Among the manuscripts, there was found one discourse wherein the archbishop took an occasion to complain of the usage which he had received from the nonjuring party, and to expose, in return, the inconsistency of their own conduct; remarking particularly, that, upon a just comparison of their principle of non-resistance with their actual non-assistance to king James II. they had little reason to boast of their loyalty to him: and yet, severe as this discourse was upon that party, Mr Nelson, notwithstanding his attachment to them, was very zealous to have it printed, alleging, that they deserved such a rebuke for their unjust treatment of so good a man. However, the sermon was then suppressed, and is now probably lost.

Our author's new character unavoidably threw him into some new connections. Among these we find mentioned particularly Mr Kettlewell, who had resigned his living at Colehill in Warwickshire on account of the new oaths, and afterwards resided in London. This pious and learned divine also agreed with him, in leaving the communion of the established church; yet at the same time persuaded him to engage in the general service of piety and devotion; observing to him, that he was very able to compose excellent books of that kind, which would be apt to do more good as coming from a layman. This address

Nelson.

corresponded with the truly catholic spirit of our author; who accordingly published many works of piety, which are deservedly esteemed. Indeed it was this spirit, more than their agreement in state principles, that first recommended them to one another. Mr Nelson is observed to have encouraged Kettlewell to proceed in that soft and gentle manner, in which he excelled, in managing the nonjurors' controversy; and animated him besides to begin and prosecute some things for a public good, which otherwise would not have seen the light. Mr Kettlewell died in 1695, and left Mr Nelson his sole executor and trustee; in consequence of which, he published a posthumous piece of piety, intitled, "An Office for Prisoners, &c." in 1697. He also published five other of his friend's posthumous pieces, and furnished the chief materials for the account of his life afterwards.

At the same time he engaged zealously in every public scheme for the honour and interest, as well as for propagating the faith, and promoting the practice, of true Christianity, both at home and abroad; several proposals for building, repairing, and endowing churches, and charity-schools particularly.

Upon the death of Dr William Lloyd, the deprived bishop of Norwich, in the end of the year 1709, he returned to the communion of the church of England. Dr Lloyd was the last surviving of the deprived bishops by the Revolution, except Dr Kenn, by whose advice Mr Nelson was determined in this point. It had been a case in view some time, which had been bandied on both sides, whether the continuance of their separation from the church should be schismatical or no, when that case became a fact; and our author had some conferences upon it with Dr Hickes, who was for perpetuating the nonjuring church, and charging the schism upon the church established. (See an account of this dispute, with some letters that passed between them on the occasion, in "The Constitution of the Catholic church, and the nature and consequences of Schism set forth, in a collection of papers written by the late George Hickes, D. D. 1716, 8vo.") Mr Nelson's tutor, Dr George Bull, bishop of St David's, dying before the expiration of this year, he was easily prevailed upon by that prelate's son to draw up an account of his father's life and writings, as he had maintained a long and intimate friendship with his lordship, which gave him an opportunity of being acquainted with his solid and substantial worth. The life was published in 1713; and as our author had long before laboured under a constitutional weakness, which had brought on an asthma and dropsy in the breast, the distemper grew to such a height soon after the publication of that work, that, for the benefit of the air, he retired at length to Kensington, where he expired on the 16th of January 1714-15, aged 59.

He was interred in the cemetery of St George's chapel, now a parochial church in Lamb's Conduit Fields, where a monument is erected to his memory, with a long and elegant Latin inscription, written by Bishop Smalridge. He was the first person buried in this cemetery; and as it was done to reconcile others to the place, who had taken an unfavourable prejudice against it, so it proved a most prevailing precedent, and had the desired effect. He pub-

lished several works of piety, and left his whole estate to pious and charitable uses, particularly to charity-schools. A good portrait of him was given by Mr Nichols, in 1779, to the company of stationers, and is placed in the parlour of their public hall. After the death of Sir Berkeley Lucy, Mr Nelson's library was sold by auction in 1760, together with that of Sir Berkeley, forming, united, a most extraordinary assemblage of devotion and infidelity. Several of Mr Nelson's original letters, highly characteristic of his benevolence, may be seen in the Anecdotes of Bowyer. Mr Nichols has also in his possession in MS. two excellent letters of advice from Mr Nelson to his young cousins George and Gabriel Hanger, on their going to settle in Turkey; which have been obligingly offered for the use of any future biographer, but are too long for our limits.

NEMAUSUS, or NEMAUSUM, (anc. geog.) the capital of the Arecomici in Gallia Narbonensis; a colony, (Coin), with the surname *Augusta*, (Inscription). In it stands a Roman amphitheatre, which is still almost entire. Now *Nîmes* in Languedoc.

NEMEA (Strabo, Livy); a river of Achaia, running between Sicyon and Corinth, the common boundary of both territories, and falling into the Corinthian bay.

NEMEA (anc. geog.), situated between Cleonæ and Philus in Argolis; whether town, district, or other thing, uncertain: there a grove stood in which the Argives celebrated the Nemean games, and there happened all the fabulous circumstances of the Nemean lion. The district Nemea is called *Bembinadia*, (Pliny); a village, *Bembina*, standing near Nemea, (Strabo). Stephanus places Nemea in Elis; though not in Elis, but on its borders; Pliny, erroneously, in Arcadia. In the adjoining mountain is still shown the den of the lion, distant 15 stadia from the place *Nemea*, (Pausanias); in which stands a considerable temple of Jupiter Nemæus and Cleonæus, from the vicinity of these two places. This place gave name to the Nemean games, celebrated every third year.

NEMEAN GAMES, so called from Nemea, a village between the cities of Cleonæ and Philus, where they were celebrated every third year. The exercises were chariot-races, and all the parts of the Pentathlon. These games were instituted in memory of Opheltes or Archemorus, the son of Euphetes and Creusa, and who was nursed by Hypsipyle; who leaving him in a meadow while she went to show the besiegers of Thebes a fountain, at her return found him dead, and a serpent twined about his neck: whence the fountain, before called *Langia*, was named *Archemorus*; and the captains, to comfort Hypsipyle, instituted these games.—Others ascribe their institution to Hercules, after his victory over the Nemean lion. Others allow, that they were instituted first in honour of Archemorus; but intermitted, and revived again by Hercules. The victors were crowned with parsley, an herb used at funerals, and feigned to have sprung from Archemorus's blood. The Argives presided at these games.

NEMESIANUS (Aurelius Olympius), a Latin poet who was born at Carthage, and flourished about the year 281, under the emperor Carus, and his sons Carinus and Numerian: the last of which emperors was so fond of poetry that he contested the glory with

Nemesianus,

Nemausus
||
Nemesia-
nus.

Nemesis
||
Nenagh.

Nemesianus, who had written a poem upon fishing and maritime affairs. We have still remaining a poem of our author called *Cygegeticon*, and four eclogues: they were published by Paulus Manutius in 1538; by Bartholet in 1613; at Leyden in 1653, with the notes of Janus Vlitias. Giraldi hath preserved a fragment of Nemesianus, which was communicated to him by Sannazarius, to whom we are obliged for our poet's works: for having found them written in Gothic characters, he procured them to be put into the Roman, and then sent them to Paulus Manutius. Although this poem hath acquired some reputation, it is greatly inferior to those of Oppian and Gratian upon the same subject; yet Nemesianus's style is natural enough, and has some degree of elegance. The world was so much possessed with an opinion of his poem in the eighth century, that it was read among the classics in the public schools, particularly in the time of Charlemagne, as appears from a letter of the celebrated Hincmar bishop of Rheims to his nephew Hincmar of Laon.

NEMESIS, in Pagan worship, the daughter of Jupiter and Necessity, or, according to others, of Oceanus and Nox, had the care of revenging the crimes which human justice left unpunished. She was also called *Adrastæa*, because Adrastus king of Argos first raised an altar to her; and *Rhamnusia*, from her having a magnificent temple at Rhamnus in Attica.—She had likewise a temple at Rome in the Capitol. She is represented with a stern countenance, holding a whip in one hand and a pair of scales in the other.

NEMESIUS, a Greek philosopher who embraced Christianity, and was made bishop of Emesa in Phœnicia, where he had his birth: he flourished in the beginning of the fifth century. We have a piece by him, intitled *De natura hominis*, in which he refutes the fatality of the Stoics and the errors of the Manichees, the Apollinarists, and the Eunomians; but he espouses the opinion of Origen concerning the pre-existence of souls (A). This treatise was translated by Valla, and printed in 1535. Another version was afterwards made of it by Ellebodus, and printed in 1665; it is also inserted in the *Bibliotheca patrum*, in Greek and Latin. Lastly, another edition was published at Oxford in 1671, folio, with a learned preface, wherein the editor endeavours to prove, from a passage in this book, that the circulation of the blood was known to Nemesius; which, however, was since shown to be a mistake by Dr Freind, in his *History of Physic*.

NEMINE CONTRADICENTE, "none contradicting it;" a term chiefly used in parliament when any thing is carried without opposition.

NEMOURS, a town of the Isle of France in the Gatinois, with the title of a duchy. It is seated on the river Loing, in E. long. 2. 45. N. lat. 48. 15.

NENAGH, a post and fair town of Ireland, in the county of Tipperary, and province of Munster, 75 miles from Dublin. It is situated on a branch of the river Shannon which runs into Lough-Derg. Here

stands the ruins of an old castle called Nenagh-round. Also those of an hospital founded in the year 1200, for canons following the rule of St Augustin. It was dedicated to St John the Baptist, and was usually called *Teachon*, or St John's house. In the reign of Henry III. a friary for conventual Franciscans was also founded here, and esteemed the richest foundation of that order in the kingdom. Here is a barrack for two troops of horse. This town was burnt on St Stephen's day 1348, by the Irish. The fairs held here are four.

NENIA, or NÆNIA, in the ancient poetry, a kind of funeral song sung to the music of flutes at the obsequies of the dead. Authors represent them as sorry compositions, sung by hired women-mourners called *Præficae*. The first rise of these Nenia is ascribed to the physicians. In the heathen antiquity, the goddess of tears and funerals was called *Nenia*; whom some suppose to have given that name to the funeral song, and others to have taken her name from it.

NEOCESARIA, (Pliny), a town of Pontus on the south or the left side of the Lycus. About the year 342, when Leontius and Sallustius were consuls, it was entirely ruined by a dreadful earthquake, no edifice having withstood the violence of the shock, except the church and the bishop's habitation, who was saved, with the clergy and some other pious persons, while the rest of the inhabitants were buried in its ruins.

NEOMAGUS, (Ptolemy); NOVIOMAGUS, (Antonine); a town of the Regni in Britain: now thought to be Guildford in Surry, (Lhuyd); or Croydon, (Talbot). But Camben takes it to be Woodcote, two miles to the south of Croydon, where traces of an ancient town are still to be seen.

NEOMAGUS, (Ptolemy); *Noviomagus*, (Antonine); a town of the Triviri on the Moselle. Now *Numagen*, 14 miles east, below Triers.

NEOMAGUS, (Ptolemy); *Noviomagus Lexoviorum*, (Antonine); a town of Gallia Celtica. Now *Lisieux*, in Normandy.

NEOMAGUS, (Ptolemy), *Noviomagus Nemetum*, (Antonine). Now *Spire*, a city of the Palatinate, on the left or west side of the Rhine.

NEOMAGUS, (Ptolemy); a town of Gallia Narbonensis, on the confines of the Tricastini. Now *Nyon* in Dauphiné.

NEOMENIA, or NOUMENIA, a festival of the ancient Greeks, at the beginning of every lunar month, which, as the name imports, was observed upon the day of the new moon, in honour of all the gods, but especially Apollo, who was called *Neomenios*, because the sun is the fountain of light; and whatever distinction of times and seasons may be taken from other planets, yet they are all owing to him as the original of those borrowed rays by which they shine.

The games and public entertainments at these festivals were made by the rich, to whose tables the poor flocked in great numbers. The Athenians at these

Nenia
||
Neomenia.

(A) It is much more probable that he and Origen both brought their opinion with them from the schools of philosophy, than that either of them borrowed it from the other. See METAPHYSICS, Part 3d. chap. 4.

Neophytes these times offered solemn prayers and sacrifices for the prosperity of their country during the ensuing month. See **GAMES**.

Nepeta.

The Jews had also their neomenia, or feast of the new moon, on which peculiar sacrifices were appointed; and on this day they had a sort of family entertainment and rejoicing. The most celebrated neomenia of all others was that at the beginning of the civil year, or first day of the month Tifri, on which no servile labour was performed: they then offered particular burnt-sacrifices, and sounded the trumpets of the temple. The modern Jews keep the neomenia only as a feast of devotion, which any one may observe or not as he pleases.

NEOPHYTES, "new plants;" a name given by the ancient Christians to those heathens who had newly embraced the faith; such persons being considered as regenerated, or born a-new by baptism. The term *neophytes* has been also used for new priests, or those just admitted into orders, and sometimes for the novices in monasteries. It is still applied to the converts made by the missionaries among the infidels.

NEPA, in zoology, a genus of insects belonging to the order of hemiptera. The rostrum is inflected; the antennæ are shorter than the thorax; and the hind-feet are hairy, and fitted for swimming. There are seven species. The four wings are folded together crosswise, with the anterior part coriaceous. The two fore feet are cheliform, or resemble the claws of a crab; the other four are formed for walking. We have but three species of this genus, all three of which are found in the water, where they dwell, as do their larvæ and chrysalids. It is likewise in the water that we find the eggs of the water-scorpion. Those eggs, of an oblong shape, have at one of their extremities two or more bristles or hairs. The insect sinks its egg into the stalk of a bull-rush or some other water-plant, so that the egg lies concealed, and only the hairs or bristles stick out, and are to be seen. One may easily preserve in water those stalks loaded with eggs, and see the young water-scorpions hatched under one's own roof, or at least their larvæ. These insects are voracious, and feed on other aquatic animals, which they pierce and tear with their sharp rostrum, while they hold them with the forceps of their fore-feet.—They fly well, especially in the evening and night, and they convey themselves from one pool to another, especially when that they are in begins to dry up. Mr Geoffroy asserts, that the pedes cheliformes, or fore-feet of the nepa, are the antennæ of the insect, which, according to him, has but four feet.

NEPENTHES, in botany: A genus of the tetrandria order, belonging to the gynandria class of plants; and in the natural method ranking among those of which the order is doubtful. The calyx is quadripartite; there is no corolla; the capsule is quadrilocular.

NEPETA, **CATMINT**, or *Nep*, in botany: A genus of the gymnospermia order, belonging to the didynamia class of plants; and in the natural method ranking under the 42d order, *Verticillata*. The under lip of the corolla has a small middle segment crenated; the margin of the throat is reflexed; the stamina approach one another. There are 14 species; the most remarkable is the cataria, common nep, or catmint. This is a native of many parts of Britain, growing about

hedges and in waste places. The stalk is a yard high, and branched; the leaves are hoary; the flowers flesh-coloured, growing verticillate in spikes at the tops of the branches: the middle segment of the lower lip is spotted with red. The plant has a bitter taste, and strong smell, not unlike pennyroyal. An infusion of this plant is reckoned a good cephalic and emmenagogue; being found very efficacious in chlorotic cases. Two ounces of the expressed juice may be given for a dose. It is called *catmint*, because cats are very fond of it, especially when it is withered; for then they will roll themselves on it, and tear it to pieces, chewing it in their mouths with great pleasure. Mr Ray mentions his having transplanted some of the plants of this sort from the fields into his garden, which were soon destroyed by the cats; but the plants which came up from seeds in his garden escaped: this verifies an old proverb, viz. "If you set it, the cats will eat it; if you sow it, the cats will not know it." Mr Withering is of opinion, that where there is a quantity of plants growing together, the cats will not meddle with them; but Mr Millar assures us, that he has frequently transplanted one of these plants from another part of the garden, within two feet of which some came up from seeds; in which case the latter have remained unhurt, when the former have been torn to pieces and destroyed: he acknowledges, however, that, where there is a large quantity of the herb growing together, they will not meddle with it. This plant is very hardy, and is easily propagated by seeds. If sown upon a poor dry soil, the plants will not grow too rank, but will continue longer, and appear much handsomer, than in rich ground, where they grow too luxuriant, and have not so strong a scent.

NEPHELIUM, in botany: A genus of the pentandria order, belonging to the monœcia class of plants. The male calyx is quinqueidentate; there is no corolla: the female calyx is quadrifid; there is no corolla.—There are two germens and two styles on each: the fruit are two dry plumbs, muricated, and monospermous.

NEPHEW, a term relative to uncle and aunt, signifying a brother's or sister's son; who, according to the civil law, is in the third degree of consanguinity, but according to the canon in the second.

NEPHRITIC, something that relates to the kidneys. See **KIDNEY**.

NEPHRITIC Wood, (*lignum nephriticum*), a wood of a very dense and compact texture, and of a fine grain, brought to us from New Spain in small blocks, in its natural state, and covered with its bark. It is to be chosen of a pale colour, sound and firm, and such as has not lost its acrid taste: for the surest test of it is the infusing it in water; for a piece of it infused only half an hour in cold water, gives it a changeable colour, which is blue or yellow as variously held to the light. If the vial it is in be held between the eye and the light, the tincture appears yellow; but if the eye be placed between the light and the vial, it appears blue. We often meet with this wood adulterated with others of the same pale colour; but the dusky black hue of the bark is a striking character of this.

The tree is the *coatli* of Hernandez. It grows to the height of our pear-tree, and its wood while fresh is much of the same texture and colour; the leaves are small and oblong, not exceeding half an inch in the

Nepeta.

Nephritic.

Nephritic
||
Neptune.

length, or a third of an inch in breadth; the flowers are small, of a pale-yellow colour, and oblong shape, standing in spikes: the cups they stand in are divided into five segments at the edge, and are covered with a reddish down. This is the best description of the tree that can be collected from what has been hitherto written of it; nobody having yet had an opportunity of taking its true characters.

This wood is said to be a very good diuretic, and we are told it is used among the Indians in all diseases of the kidneys and bladder, and in suppression of urine, from whatever cause. It is also recommended in fevers, and in obstructions of the viscera. The way of taking it among the Indians is only an infusion in cold water. These uses are not however properly ascertained. See *GUILANDINA*.

NEPHRITIC Stone. See *JADE-Stone*.

NEPHRITICS, in pharmacy, medicines proper for diseases of the kidneys, especially the stone.—Such particularly are the roots of althæa, dog's grass, asparagus, sago, pellitory of the wall, mallows, pimpinella, red chick-pease, peach-kernels, turpentine, &c.

NEPHRITIS, or inflammation of the kidneys. See *MEDICINE*, n° 200.

NEPOS (Cornelius), a celebrated Latin biographer, who flourished in the time of Julius Cæsar, and lived, according to St Jerome, to the sixth year of Augustus. He was an Italian, if we may credit Catullus, and born at Hostilia, a small town in the territory of Verona, in Cisalpine Gaul. Ausonius, however, will have it that he was born in the Gauls: and in that they may both be in the right, provided that under the name of *Gaul* is comprehended *Gallia Cisalpina*, which is in Italy. Leander Alberti thinks Nepos's country was Verona; and he is sure that he was either born in that city or neighbourhood. For the rest, Cicero and Atticus were friends of our author; who wrote the lives of the Greek historians, as he himself attests in that of Dion, speaking of Philistus. What he says, also, in the lives of Cato and Hannibal, proves that he had also written the lives of the Latin captains and historians. He wrote some other excellent works which are lost.

All that we have left of his at present is, "The Lives of the illustrious Greek and Roman Captains;" which were a long time ascribed to Æmilius Probus, who published them, as it is said, under his own name, to insinuate himself thereby into the favour of the emperor Theodosius; but, in the course of time, the fraud has been discovered, although several learned persons have confounded the two authors. This piece has been translated into French by the Sieur de Claveret, with a dedication to the duke of Longueville, in 1663; and again by M. le Gras, then of the congregation of the oratory at Paris 1729, 12mo. We have an excellent translation of it in English, by several hands at Oxford, which has gone through several editions.

NEPTUNE in Pagan worship, the god of the sea, was the son of Saturn and Vesta, or Ops, and the brother of Jupiter and Pluto. He assisted Jupiter in his expeditions; on which that god, when he arrived at the supreme power, assigned him the sea and the islands for his empire. He was, however, expelled

from heaven with Apollo for conspiring against Jupiter, when they were both employed by Laomedon king of Phrygia in building the walls of Troy; but that prince dismissing Neptune without a reward, he sent a sea-monster to lay waste the country, on which he was obliged to expose his daughter Hesione. He is said to have been the first inventor of horsemanship and chariot racing; on which account Mithridates king of Pontus threw chariots drawn by four horses into the sea in honour of this god; and the Romans instituted horse-races in the circus at his festival, during which all other horses left working, and the mules were adorned with wreaths of flowers.

In a contest with Minerva he produced a horse by striking the earth with his trident; and on another occasion, in a trial of skill with Minerva and Vulcan, produced a bull, whence that animal was sacrificed to him. His favourite wife was Amphytrite, whom he long courted in vain, till sending the dolphin to intercede for him, he met with success; on which he rewarded the dolphin by placing him among the stars. He had also two other wives, one of whom was called *Salasia* from the salt-water; the other *Venilia* from the ebbing and flowing of the tides. He had likewise many concubines, by whom he had a great number of children. He is represented with black hair, with a garment of an azure or sea-green, holding his trident in his hand, and seated in a large shell drawn by sea-horses, attended by the sea-gods Palemon, Glaucus, and Phorcys, and the sea-goddesses Thetis, Melita, and Panopæa, and a long train of tritons and sea-nymphs.

This deity was in Egypt known by the name of *Genobus* or *Canopus*, and was worshipped as the *numen aquarum* or spirit of the Nile. His emblem was the figure of certain vases or pitchers, with which the Egyptians filtrated the water of their sacred river, in order to purify it and render it fit for use. From the mouth of each of these vases, which were charged with hieroglyphics, arose the head, and sometimes the head and hands, of a man or woman. Such are the emblems which still remain of the Egyptian Neptune or Canopus; and it was by this emblem that the tutelar god of Egypt vanquished the god of Chaldea in the ridiculous manner mentioned by Ruffinus in his ecclesiastical history*.

"The Chaldeans (says he) who adored the fire, carried their god into various countries that he might try his strength in contests with other gods. He vanquished, as we may easily conceive, the images made of gold, silver, brass, and wood, &c. by reducing them to ashes; and thus the worship of fire was every where established. The priest of Canopus, unwilling, as became him, to admit the superiority of strange gods, contrived to make his god vanquish the god of Chaldea in a pitched battle. The vases which were worshipped as the emblems of Canopus being used for filtering the waters of the Nile, were of course perforated on all sides with very small holes. This faithful priest having stopped all the holes in one of these with wax, and painted the vase of different colours for a reason which the reader will admit to be a good one, filled it up with water, and fitted to its mouth the head of an idol. This emblem of Canopus was then placed in a small fire brought by the Chal-

Neptune.

* *Lib. 1. cap. 26.*

Nereids,
Nereis.

Chaldeans as the emblem of their god; and thus the gods of Egypt and Chaldaea were forced into battle. The contest, however, was of short duration. The heat melting the wax made way for the water to run out, which quickly extinguished the fire; and thus Canobus vanquished the god of the Chaldeans." Ridiculous as this story is, it is perfectly suitable to the genius of paganism and the mean artifices of the pagan priesthood; but we suspect that the historian laboured under one mistake, and substituted the Chaldeans instead of the Persians. See POLYTHEISM.

NEREIDS, in the Pagan theology, sea nymphs, daughters of Nereus and Doris.—The Nereids were esteemed very handsome; insomuch that Cassiope, the wife of Cepheus king of Ethiopia, having triumphed over all the beauties of the age, and daring to vie with the Nereids, they were so enraged that they sent a prodigious sea-monster into the country; and, to appease them, she was commanded by the oracle to expose her daughter Andromeda, bound to a rock, to be devoured by the monster. In ancient monuments, the Nereids are represented riding upon sea-horses; sometimes with an entire human form, and at other times with the tail of a fish.

NEREIS, in zoology, a genus of animals belonging to the order of vermes mollusca. The body is oblong, linear, and fitted for creeping; it is furnished with lateral pencilled tentacula. There are 11 species; of which the most remarkable are the five following: 1. The *Noctiluca*, or noctilucous nereis, which inhabits almost every sea, and is one of the causes of the luminousness of the water. These creatures shine like glow-worms, but with a brighter splendour, so as at night to make the element appear as if on fire all around. Their bodies are so minute as to elude examination by the naked eye.

It is sometimes called *nereis phosphorans*; and is thus described by Griseb.: The head is roundish and flat, and the mouth acuminate. The two horns or feelers are short and subulated. The eyes are prominent, and placed on each side the head. The body is composed of about 23 segments or joints, which are much less nearer the tail than at the head. These segments on both sides the animal all end in a short conical apex, out of which proceeds a little bundle of hairs: from under these bundles the feet grow in the form of small flexile subulated filaments destitute of any thing like claws. It is scarcely two lines long, and is quite pellucid, and its colour is that of water green. They are found upon all kinds of marine plants; but they often leave them and are found upon the surface of the water: they are frequent at all seasons, but especially in summer before stormy weather, when they are more agitated and more luminous. Their numbers, and wonderful agility, added to their pellucid and shining quality, do not a little contribute to their illuminating the sea, for myriads of those animalculæ may be contained in the portion of a small cup of sea-water. Innumerable quantities of them lodge in the cavities of the scales of fishes, and to them probably do the fishes owe their noctilucous quality. "I have observed with great attention (says Barbut), a fish just caught out of the sea, whose body was almost covered with them; and have examined them in the dark: they twist and

N^o 241.

curl themselves with amazing agility, but soon retire out of our contracted sight; probably their glittering numbers dazzling the eye, and their extreme minuteness eluding our researches. It is to be observed, that when the unctuous moisture which covers the scales of fishes is exhausted by the air, these animals are not to be seen; nor are the fishes then noctilucous, that matter being perhaps their nourishment when living, as they themselves afford food to many marine animals. They do not shine in the day-time, because the solar rays are too powerful for their light; however aggregate or immense their number." Their appearance is particularly brilliant when the wind is in the east and south-east points, and in winter-nights preceded by a warm day. If water containing these animalcules be kept warm, they retain their light two whole days after they are dead; but in cold water lose it in eight hours: motion and warmth, which increase their vivacity and strength, increase their light also.

2. *Nereis lacustris*, or bog nereis. The body of the size of a hog's short bristle, transparent, as it were articulated, and on either side at every articulation provided with a short setaceous foot; interiorly it seems to consist in a manner of oval shaped articulations, and a back formed by two lines bent backwards. It inhabits marshes abounding in clay, where it remains under ground, pushing out its other extremity by reason of its continual motion. When taken out it twists itself up. Is frequent in Sweden.

3. *Nereis cirrosa*, or waving nereis. The body is red, lumbriciform, with 65 notches, furnished on both sides with two rows of bristles. At each side of the head ten filaments, at the sides of the mouth many, twice as long as the former. It dwells in Norway, on rocks at the bottom of the sea. It vomits a red liquor with which it tinges the water.

4. *Nereis carulea*, or blue nereis. It inhabits the ocean; where it destroys the serpulæ and teredines.

5. *Nereis gigantea*, or giant nereis. This is a peculiar species of those large worms that make their way into decayed piles driven down into the sea, which they bore through and feed upon, whence they are called *sea worms* or nereis. From head to tail they are beset on either side with small tufts terminating in three points; which are like the fine hair pencils used by painters, and composed of shining bristles of various colours. The upper part of the body in this worm is all over covered with small hairs. The rings of which it is formed are closely pressed together, and yield to the touch. The three rows of small tufts we have been describing, serve this nereis instead of feet, which it uses to go forwards as fishes do their fins.

NEREUS, (fab. hist.), a marine deity, was the son of Oceanus and Thetis. He settled in the Ægean Sea, was considered as a prophet, and had the power of assuming what form he pleased. He married his sister Doris, by whom he had 50 daughters called the *Nereids*, who constantly attended on Neptune, and when he went abroad surrounded his chariot.

NERI (S. Philippe de), founder of the congregation of the Oratory in Italy, was born of a noble family at Florence, on the 25th of July 1515. Educated in the principles of piety and learning, he soon became

Nereis
||
Neri.

Plate
CCCXLV.
fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Neri
||
Nero.

became distinguished for his knowledge and virtue. At the age of 19 he went to Rome, where he improved his mind, assisted the sick, and gave many proofs of self-denial and humility. Philippe, being raised to the priesthood at the age of 36, instituted, in 1550, a celebrated fellowship in the church of St. Saviour del Campo, for the relief of poor foreigners, of pilgrims, and of convalescents, who had no place whither they could retire. This society was the cradle, if we may say so, of the congregation of the Oratory. The holy founder having gained over to God Salviati brother to the cardinal of the same name, Tarugio afterwards cardinal, the celebrated Baronius, and several others, they began to form themselves into a society in 1564. The spiritual exercises had been transferred in 1558 to the church of Saint Jerom de la Charité, which Philippe did not leave till 1574, when he went to stay at Saint John of the Florentines. Pope Gregory XIII. gave his approbation of the congregation in the following year. The father of this new warfare sent out some of his children, by whom his order was spread throughout Italy. Nor is there any reason to be surprised at its rapid success. No vow is taken in this congregation; charity is the only bond of connection. The general continues only three years in office, and his orders are not those of a tyrant or a despot. The founder died at Rome on the night between the 25th and 26th of May 1595, aged 80. He had resigned the generalship three years before in favour of Baronius, who, by his advice, was engaged in the ecclesiastical annals. The constitutions which he left for his congregation were not printed till 1612. The principal employment which he allots to the priests of his order, is to give, every day, in their oratory or church, instructions suited to the understandings of their hearers: an office truly apostolical, and which the followers of Neri discharge with success. They humble themselves, that they may exalt to God the soul of the simple. Philippe was canonised in 1622 by Gregory XV.

There was a learned man of the name of NERI (Anthony), from whom we have a curious book printed at Florence 1612, in 4to, with this title *Dell'Arte verraria libri VII.*; and a Dominican named Thomas Neri, who employed his pen in defence of his fellow monk, the famous Savonarole.

NERIUM, in botany: A genus of the monogynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 30th order, *Contortæ*. There are two erect follicles; the seeds plummy; the tube of the corolla terminated by a lacerated crown. There are five species, all of them natives of the warmer climates: the most remarkable of which are, 1. The oleander, South-Sea rose: this is a beautiful shrub, cultivated in gardens on account of its flowers, which are of a fine purple, and in clusters, but of an indifferent smell: the whole plant is poisonous, and especially the bark of the roots. 2. The antidysentericum, a native of Ceylon: the bark of which is an article of materia medica, under the name of *Coneffi*. 3. The tinctorium, a new species with beautiful blue flowers lately discovered by Dr Roxburgh at Madras. A decoction of the leaves, with an addition of lime-water, makes an indigo of fine quality.

NERO (Claudius Domitius Cæsar), a celebrated

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Roman emperor, son of Caius Domitius Ahenobarbus and Agrippina the daughter of Germanicus. He was adopted by the emperor Claudius, A. D. 50, and four years after he succeeded to him on the throne. In the beginning of his reign he showed several marks of the greatest kindness and condescension, affability, complaisance, and popularity. The object of his administration seemed to be the good of his people; and when he was desired to sign his name to a list of malefactors that were to be executed, he exclaimed, *Would to heaven I could not write!* He hated flattery; and when the senate had liberally commended the wisdom of his government, he desired them to keep their praises till he deserved them. These promising virtues soon, however, proved to be artificial: Nero soon displayed the real propensities of his nature. He delivered himself from the sway of his mother, and at last ordered her to be murdered. This unnatural act of barbarity might astonish some, but Nero had his devoted adherents; and when he declared that he had taken away his mother's life to save himself from ruin, the senate applauded his measures, and the people signified their approbation. Many of his courtiers shared her unhappy fate; and Nero sacrificed to his fury or caprice all such as obstructed his pleasure or diverted his inclination. In the night he generally went from his palace to visit the meanest taverns, and all the scenes of debauchery which Rome contained. In this nocturnal riot he was fond of insulting the people in the streets; and his attempts to offer violence to the wife of a Roman senator nearly cost him his life. He also turned actor, and openly appeared on the Roman stage in the meanest characters. In his attempts to excel in music, and to conquer the disadvantages of a hoarse disagreeable voice, he moderated his meals, and often passed the day without eating. The Olympian games attracted his notice: he went into Greece, and presented himself a candidate for the public honour. He was defeated in wrestling; but the flattery of the spectators adjudged him the victory, and he returned to Rome with all the pomp and splendor of an eastern conqueror, drawn in the chariot of Augustus, and attended by a band of musicians, actors, and stage-dancers from every part of the empire. These private and public amusements of the emperor were indeed innocent; his character only was injured, and not the lives of the people. His conduct, however, soon became more abominable: he disguised himself in the habit of a woman, and was publicly married to one of his eunuchs. This violence to nature and decency was soon exchanged for another: Nero resumed his sex, and celebrated his nuptials with one of his meanest catamites: and it was on this occasion that one of the Romans observed that the world would have been happy if Nero's father had had such a wife. But his cruelty was now displayed in a still higher degree, for he sacrificed to his wantonness his wife Octavia Poppæa, and the celebrated writers, Seneca, Lucan, Petronius, &c. Nor did the Christians escape his barbarity. He had heard of the burning of Troy; and as he wished to renew that dismal scene, he caused Rome to be set on fire in different places. The conflagration became soon universal, and during nine successive days the fire continued. All was desolation: nothing was heard but the lamentations of mothers

Nero.

B

whose

Nero.

whose children had perished in the flames, the groans of the dying, and the continual fall of palaces and buildings. Nero was the only one who enjoyed the general consternation. He placed himself on the top of a high tower, and he sung on his lyre the destruction of Troy, a dreadful scene which his barbarity had realised before his eyes. He attempted to avert the public odium from his head by a pretended commiseration of the miseries of his subjects. He began to repair the streets and the public buildings at his own expence. He built himself a celebrated palace, which he called his golden house. It was liberally adorned with gold, with precious stones, and with every thing rare and exquisite. It contained spacious fields, artificial lakes, woods, gardens, orchards, and whatever exhibited a beautiful scene. The entrance of this edifice could admit a large colossus of the emperor 120 feet high; the galleries were each a mile long, and the whole was covered with gold. The roofs of the dining halls represented the firmament, in motion as well as in figure; and continually turned round night and day, showering down all sorts of perfumes and sweet waters. When this grand edifice, which, according to Pliny, extended all round the city, was finished, Nero said, that now he could lodge like a man. His profusion was not less remarkable in all his other actions. When he went a fishing, his nets were of gold and silk. He never appeared twice in the same garment; and when he took a voyage, there were thousands of servants to take care of his wardrobe. This continuation of debauchery and extravagance at last roused the people. Many conspiracies were formed against him; but they were generally discovered, and such as were accessory suffered the severest punishments. The most dangerous conspiracy against Nero's life was that of Piso, from which he was saved by the confession of a slave. The conspiracy of Galba proved more successful, who, when he was informed that his plot was known to Nero, declared himself emperor. The unpopularity of Nero favoured his cause; he was acknowledged by all the Roman empire, and the senate condemned the tyrant to be dragged naked through the streets of Rome, and whipped to death, and afterwards to be thrown down from the Tarpeian rock like the meanest malefactor. This, however, was not executed; for Nero prevented it by a voluntary death. He killed himself, A. D. 68, in the 32d year of his age, after a reign of 13 years and eight months. Rome was filled with acclamations at it; and the citizens, more strongly to indicate their joy, wore caps, such as were generally used by slaves who had received their freedom. Their vengeance was not only exercised against the statues of the deceased monster, but many of his friends were the object of the public resentment; and many were crushed to pieces in such a violent manner, that one of the senators, amid the universal joy, said that he was afraid they should soon have cause to wish for Nero. The tyrant, as he expired, requested that his head might not be cut off from his body, and exposed to the insolence of the populace, but that the whole might be burned on the funeral pile. His request was granted by one of Galba's freedmen, and his obsequies were performed with the usual ceremonies. Though his death seemed to be the source of general gladness, yet many of his favourites

lamented his fall, and were grieved to see that their pleasures and amusements were stopped by the death of this patron of debauchery and extravagance. Even the king of Parthia sent ambassadors to Rome, to condole with the Romans, and to beg that they would honour and revere the memory of Nero. His statues were also crowned with garlands of flowers; and many imagined that he was not dead, but that he would soon make his appearance and take vengeance on his enemies. It will be sufficient to observe, in finishing the character of this tyrannical monster, that the name of *Nero* is even now used emphatically to express a barbarous and unfeeling oppressor. Pliny calls him the common enemy and fury of mankind; and so indeed he has been called by all writers, who exhibit Nero as a pattern of the most execrable barbarity and unpardonable wantonness. The same Pliny furnishes us with this singular anecdote of him: "Nero had ordered himself to be painted under the figure of a colossus, upon cloth or canvas, 120 feet in height." He adds, "that this preposterous picture, when it was finished, met with its fate from lightning, which consumed it, and involved likewise the most beautiful part of the gardens where it was placed in the conflagration."

NERVA (Cocceius), a Roman emperor after Domitian, who was the last of the 12 Cæsars. He was a native of Narnia in Umbria; his family however was originally of Crete. Dio Cassius says he was born on the 17th of March, in the 18th year of Tiberius's reign, and of the Christian æra the 32d. Nero in the 12th year of his reign made him prætor, and erected a statue for him in the palace on account of his poems (for he was one of the best poets of his age), some of which were inscribed to him. He was consul in 71 with Vespasian, and in 90 with Domitian.

Ancient authors uniformly celebrate him as a prince of a most mild and humane temper, of great moderation and generosity, who looked on his office as emperor, not as if it was for his own advantage, but for that of his people; and whilst he reigned, which was however but for a short time, he made the happiness of his subjects his only end and pursuit. He narrowly escaped death under Domitian; was naturally of a weak and timorous disposition; and, as some say, addicted to excessive drinking. The Romans unanimously chose him emperor; and they had no cause to repent of their choice, for he was constantly attentive to what could make them happy; he was generous, merciful, and disinterested. An instance of his great lenity appears in his pardoning Calpurnius Crassus who conspired against him. In short, he omitted nothing that might contribute to the restoring of the empire to its former lustre; recalling those who had been banished for religion, and redressing all grievances that came to his knowledge. He however found his strength failing, and that it would be impossible for him to finish his designs, in consequence of which he adopted Trajan. After his death, which happened in the year 98, he was ranked among the gods. He was the first Roman emperor of foreign extraction.

NERVES, in anatomy, certain white glistening cords, proceeding from the brain and spinal marrow, and dividing into very small branches, which are sent off throughout all parts of the body; and which are found

Nerva,
Nerves.

Nervous found to be the organs of sensation and motion. See *ANATOMY*, n° 136.

Nestor. *NERVOUS FLUID.* See *ANATOMY*, n° 136.

NESSUS (fab. hist.), a celebrated centaur, son of Ixion and the Cloud. He offered violence to Dejanira whom Hercules had entrusted to his care, with orders to carry her across the river Evenus. Hercules saw the distress of his wife from the opposite shore of the river, and immediately he let fly one of his poisoned arrows, which struck the centaur to the heart. Nessus, as he expired, gave the tunic he then wore to Dejanira, assuring her that from the poisoned blood which had flowed from his wounds, it had received the power of calling a husband away from unlawful loves. Dejanira received it with pleasure, and this mournful present caused the death of Hercules. — A river which separates Thrace from Macedonia. It is also called *Nefus*, *Nestor*, and *Nestus*.

NEST. See *NIDUS*.

Eatable Birds Nests. See *BIRDS Nests*.

NESTOR (fab. hist.), a son of Neleus and Chloris, nephew to Pelias and grandson to Neptune. He had eleven brothers, who were all killed with his father by Hercules. His tender age detained him at home, and was the cause of his preservation. The conqueror spared his life and placed him upon the throne of Pylos. He married Eurydice the daughter of Clymenus; or, according to others, Anaxibia the daughter of Atreus. He soon distinguished himself in the field of battle; and was present at the nuptials of Perithous, when a bloody engagement took place between the Lapithæ and centaurs. As king of Pylos and Messenia he led his subjects to the Trojan war, where he distinguished himself among the rest of the Grecian chiefs, by eloquence, address, wisdom, justice, and uncommon prudence. Homer displays his character as the most perfect of all his heroes; and Agamemnon exclaims, that if he had 20 generals like Nestor, he should soon see the walls of Troy reduced to ashes. After the Trojan war Nestor retired to Greece, where he enjoyed in the bosom of his family the peace and tranquillity which were due to his wisdom and to his age. The manner and the time of his death are unknown: the ancients are all agreed that he lived three generations of men; which length of time is supposed to be 300 years, though more probably only 90 years, allowing 30 years for each generation. From that circumstance, therefore, it was usual among the Greeks and the Latins, when they wished a long and happy life to their friends, to wish them to see the years of Nestor. He had many children; two daughters, Pisidice and Polycaeste; and seven sons, Perseus, Straticus, Aretus, Echephron, Pisistratus, Antilochus, and Trafimedes. Nestor was one of the Argonauts, according to Valerius Flaccus, v. 380, &c. — A poet of Lycaonia in the age of the emperor Severus. He was father to Pisander, who under the emperor Alexander wrote some fabulous stories. — One of the body guards of Alexander.

NESTOR, whose secular name is not known, was a native of Russia, and the earliest historian of the north. He was born in 1056 at Bielozero; and in the 19th year of his age he assumed the monastic habit in the convent of Petcherski at Kief, and took the name of *Nestor*. He there made a considerable proficiency in

the Greek language: but seems to have formed his style and manner rather from the Byzantine historians, Cedrenus, Zonaras, and Syncellus, than from the ancient classics. The time of Nestor's death is not ascertained; but he is supposed to have lived to an advanced age, and to have died about the year 1115.

His great work is his Chronicle, to which he has prefixed an introduction, which, after a short sketch of the early state of the world, taken from the Byzantine writers, contains a geographical description of Russia and the adjacent regions; an account of the Slavonian nations, their manners, their emigrations from the banks of the Danube, their dispersion, and settlement in the several countries wherein their descendants are now established. He then enters upon a chronological series of the Russian annals, from the year 858 to about 1113. His style is simple and unadorned, such as suits a mere recorder of facts; but his chronological exactness, though it renders his narrative dry and tedious, contributes to ascertain the æra and authenticity of the events which he relates.

It is remarkable (says Mr Coxe, from whom we have taken this narrative), that an author of such importance, whose name frequently occurs in the early Russian books, should have remained in obscurity above 600 years; and been scarcely known to his modern countrymen, the origin and actions of whose ancestors he records with such circumstantial exactness. A copy of his Chronicle was given in 1668 by prince Radzivil to the library of Konigsburgh, where it lay unnoticed until Peter the Great, in his passage through that town, ordered a transcript of it to be sent to Petersburg. But it still was not known as the performance of Nestor: for when Muller in 1732 published the first part of a German translation, he mentioned it as the work of the abbot Theodosius of Kiof; an error which arose from the following circumstance: The ingenious editor, not being at that time sufficiently acquainted with the Slavonian tongue, employed an interpreter, who, by mistaking a letter in the title, supposed it to have been written by a person whose name was Theodosius. This ridiculous blunder was soon circulated, and copied by many foreign writers, even long after it had been candidly acknowledged and corrected by Muller.

NESTORIANS, a sect of ancient Christians, still said to be subsisting in some parts of the Levant; whose distinguishing tenet is, that Mary is not the mother of God. They take their name from Nestorius bishop of Constantinople, whose doctrines were spread with much zeal through Syria, Egypt, and Persia.

One of the chief promoters of the Nestorian cause was Barsumas, created bishop of Nisibis, A. D. 435. Such was his zeal and success, that the Nestorians, who still remain in Chaldea, Persia, Assyria, and the adjacent countries, consider him alone as their parent and founder. By him Pherozes the Persian monarch was persuaded to expel those Christians who adopted the opinions of the Greeks, and to admit the Nestorians in their place, putting them in possession of the principal seat of ecclesiastical authority in Persia, the see of Seleucia, which the patriarch of the Nestorians has always filled even down to our time. — Barsumas also erected a school at Nisibis, from which

Nestorians. proceeded those Nestorian doctors who in the fifth and sixth centuries spread abroad their tenets through Egypt, Syria, Arabia, India, Tartary, and China.

He differed considerably from Nestorius, holding that there are two persons in Jesus Christ, as well as that the Virgin was not his mother as God, but only as man.

The abettors of this doctrine refuse the title Nestorians; alleging that it had been handed down from the earliest times of the Christian church.

In the tenth century, the Nestorians in Chaldea, whence they are sometimes called *Chaldeans*, extended their spiritual conquests beyond mount Imaus, and introduced the Christian religion into Tartary, properly so called, and especially into that country called *Karrit*, and bordering on the northern part of China. The prince of that country, whom the Nestorians converted to the Christian faith, assumed, according to the vulgar tradition, the name of *John* after his baptism, to which he added the surname of *Presbyter*, from a principle of modesty; whence it is said his successors were each of them called *Presbyter John* until the time of Gengis Khan. But Mosheim observes, that the famous Presbyter John did not begin to reign in that part of Asia before the conclusion of the 11th century. The Nestorians formed so considerable a body of Christians, that the missionaries of Rome were industrious in their endeavours to reduce them under the papal yoke. Innocent IV. in 1246, and Nicolas IV. in 1278, used their utmost efforts for this purpose, but without success. Till the time of pope Julius III the Nestorians acknowledged but one patriarch, who resided first at Bagdad, and afterwards at Mousul; but a division arising among them, in 1551 the patriarchate became divided, at least for a time, and a new patriarch was consecrated by that pope, whose successors fixed their residence in the city of Ormus, in the mountainous part of Persia, where they still continue, distinguished by the name of *Simeon*; and so far down as the last century, these patriarchs persevered in their communion with the church of Rome, but seem at present to have withdrawn themselves from it. The great Nestorian pontiffs, who form the opposite party, and look with a hostile eye on this little patriarch, have since the year 1559 been distinguished by the general denomination of *Elias*, and reside constantly in the city of Mousul. Their spiritual dominion is very extensive, takes in a great part of Asia, and comprehends also within its circuit the Arabian Nestorians, and also the Christians of St Thomas, who dwell along the coast of Malabar. It is observed, to the lasting honour of the Nestorians, that of all the Christian societies established in the East, they have been the most careful and successful in avoiding a multitude of superstitious opinions and practices that have infected the Greek and Latin churches. About the middle of the 17th century, the Romish missionaries gained over to their communion a small number of Nestorians, whom they formed into a congregation or church; the patriarchs or bishops of which reside in the city of Amida, or Diarbeker, and all assume the denomination of *Joseph*. Nevertheless the Nestorians in general persevere to our own times in their refusal to enter into the communion of the Romish church, notwithstanding the

earnest intreaties and alluring offers that have been made by the pope's legate to conquer their inflexible constancy. **Nestorius.**

NESTORIUS, from whom the sect of Nestorian Christians derive their name, was born in Germanica a city of Syria. He received his education at Antioch, where he was likewise baptized; and soon after his baptism he withdrew himself to a monastery in the suburbs of that city. Upon his being admitted to the order of priesthood, he quickly acquired so great reputation by the eloquence of his preaching, and the regularity of his life, that by the emperor Theodosius he was deemed a fit person to fill the second see in the Christian church, and was accordingly consecrated bishop of Constantinople in the year 429.

In one of his first sermons after his promotion, he publicly declared his intention to *make war upon heretics*; and with that intolerant spirit which has so often disgraced the preachers of the mild religion of Jesus, he called upon the emperor to *free the earth from heretics*, promising to give him heaven as a reward for his zeal. To this spiritual motive he added one, that, though carnal, he possibly judged of equal force: "Join with me (said he) in war against them, and I will assist you against the Persians." Although the wiser and better part of his audience were amazed to see a man, before he had tasted (as the historian * ex- * Socrates. presses himself) the water of his city, declare that he would persecute all who were not of his opinion; yet the majority of the people approved of this discourse, and encouraged him to execute his purpose. Accordingly, five days after his consecration, he attempted to demolish the church in which the Arians secretly held their assemblies; and he succeeded so far in his design, that these people, growing desperate, set it on fire themselves, and consumed with it some of the neighbouring houses. This fire excited great commotions in the city, and Nestorius was ever afterwards called an *incendiary*.

From the Arians he turned his persecution against the Novatians, but was stopped in his career by the interposition of the emperor. He then let loose his fury upon those Christians of *Asia*, *Lydia*, and *Caria*, who celebrated the feast of Easter upon the 14th day of the moon; and for this unimportant deviation from the Catholic practice, many of those people were murdered by his agents both at Miletum and at Sardis. One cannot be sorry that such a relentless persecutor should himself be afterwards condemned as an heretic, for holding an opinion which no man who speaks or thinks with philosophic accuracy will now venture to controvert. This obnoxious tenet, which produced a schism in the church, and was condemned by a general council, was nothing more than that "the Virgin Mary cannot with propriety be called the mother of God." The people being accustomed to hear this expression, were much inflamed against their bishop, imagining that he had revived the error of *Paulus Samosetenus* and *Photinus*, who taught that Jesus Christ was a mere man. The monks declared openly against him, and, with some of the most considerable men in Constantinople, separated themselves from his communion. Several bishops wrote to him earnest persuasives to acknowledge that Mary was the mother of God; and when he would not comply, they procured his con-

Nestorius condemnation in the council of Ephesus, which deprived him of his see. He then retired to his ancient monastery at Antioch, whence he was taken four years afterwards by the emperor's order, and banished in 435 to Tarsus. That city being taken and destroyed by the barbarians, he was removed to Panopolis, a city of Thebais; where he was not suffered to remain long, but was compelled to go from place to place, till, being in one of his journey's mortally bruised by a fall, death relieved him from the fury of his persecutors.

If we examine such of his writings as remain, we shall find that he was very unjustly condemned. It appears that he rejected the errors of *Ebion*, *Paulus Samosatenus*, and *Photinus*; that he maintained in express terms, that the divine Word was united to the human nature in Jesus Christ in the most strict and intimate sense possible; that these two natures, in this state of union, make but one Christ and one person; that the properties of the Divine and human natures may both be attributed to this person; and that Jesus Christ may be said to have been born of a virgin, to have suffered and died; but he never would admit that God could be said to have been born, to have suffered, or to have died. — When we consider that every person partakes of the substance of his mother, and that it is this which constitutes the parental and filial relation between them, it is indeed surprising that the expression "Mother of God" should ever have been admitted into the Christian church, or that any man who understands the meaning of the words should condemn Nestorius for not having used them.

NESTUS, or **NESSUS**, a river which separates Thrace from Macedonia. It falls into the *Ægean* sea near the island *Thasos*. It is sometimes called *Nessus* and *Nessus*.

NET, a device for catching fish and fowl. See the article **FISHERY**.

The taking fowls by nets is the readiest and most advantageous of all others, where numbers are to be taken. The making the nets is very easy, and what every true sportsman ought to be able to do for himself. All the necessary tools are wooden needles, of which there should be several of different sizes, some round and others flat; a pair of round pointed and flat scissars; and a wheel to wind off the thread. The packthread is to be of different strength and thickness, according to the sort of birds to be taken; and the general size of the meshes, if not for very small birds, is two inches from point to point. The nets should neither be made too deep nor too long, for they are then difficult to manage; and they must be verged on each side with twisted thread. The natural colour of the thread is too bright and pale, and is therefore in many cases to be altered. The most usual colour is the russet; which is to be obtained by plunging the net, after it is made, into a tanner's pit, and letting it lie there till it be sufficiently tinged: this is of a double service to the net, since it preserves the thread as well as alters the colour. The green colour is given by chapping some green wheat and boiling it in water, and then soaking the net in this green tincture. The yellow colour is given in the same manner with the decoction of celandine; which gives a pale straw-colour, which is the colour of stubble in the harvest-

time. The brown nets are to be used on ploughed lands, the green on grass grounds, and the yellow on stubble-lands.

Net-Day, among fowlers, a net generally used for taking such small birds as play in the air, and will stoop either to prey, gig, or the like; as larks, linnets, buntings, &c. The time of the year for using this net is from August to November; and the best time is very early in the morning; and it is to be observed, that the milder the air, and the brighter the sun is, the better will be the sport, and of longer continuance. The place where this net should be laid, ought to be plain champaign, either on short stubbles, green lays, or flat meadows, near corn-fields, and somewhat remote from towns and villages: you must be sure to let your net lie close to the ground, that the birds creep not out and make their escape. — The net is made of a fine packthread with a small mesh, not exceeding half an inch square; it must be three fathoms long, and but one broad: it must be verged about with a small but strong cord; and the two ends extended upon two small long poles, suitable to the breadth of the net, with four stakes, tail-strings, and drawing-lines. — This net is composed of two, which must be exactly alike; and are to be laid opposite to one another, so even and close, that when they are drawn and pulled over, the sides must meet and touch each other. You must stake this net down with strong stakes, very stiff on their lines, so that you may with a nimble touch cast them to and fro at pleasure; then fasten your drawing-cords or hand-lines (of which there must be a dozen at least, and each two yards long) to the upper end of the foremost stakes: and so extend them of such a straightness, that with a little strength they may rise up in the nets, and cast them over.

Your nets being thus laid, place your gigs, or playing-wantons, about 20 or 30 paces beyond, and as much on this side your nets: the gigs must be fastened to the tops of long poles, and turned into the wind, so as they may play to make a noise therein. These gigs are a sort of toys made of long goose-feathers, like shuttle-cocks, and with little small tunnels of wood running in broad and flat swan-quills, made round like a small hoop; and so, with longer strings fastened to a pole, will, with any small wind or air, move after such a manner, that birds will come in great flocks to play about them.

When you have placed your gigs, then place your stake; which is a small stake of wood, to prick down into the earth, having in it a mortice-hole, in which a small and slender piece of wood, about two feet long, is fastened, so as it may move up and down at pleasure: and fasten to this longer stick a small line, which, running through a hole in the stick above-mentioned, and so coming up to the place where you are to sit, you may, by drawing the line up and down, with your right hand, raise up the longer stick as you see occasion.

Fasten a live lark, or such like bird, to this longer stick, which, with the line making it to stir up and down by your pulling, will entice the birds to come to your net.

There is another stake, or enticement, to draw on these birds, called a *looking glass*; which is a round stake of wood, as big as a man's arm, made very sharp

Net.

Sportsman's
Dict.

Net.

at the end, to thrust it into the ground: they make it very hollow in the upper part, above five fingers deep; into which hollow they place a three-square piece of wood about a foot long, and each two inches broad, lying upon the top of the stake, and going with a foot into the hollowness: which foot must have a great knob at the top, and another at the bottom, with a deep slenderness between; to which slenderness you are to fasten a small packthread, which, running through a hole in the side of the stake, must come up to the place where you sit. The three-square piece of wood which lies on the top of the stake, must be of such a poise and evenness, and the foot of the socket so smooth and round, that it may whirl and turn round upon the least touch; winding the packthread so many times about it, which being suddenly drawn, and as suddenly let go, will keep the engine in a constant rotatory motion: then fasten with glue on the uppermost flat squares of the three-square piece, about 20 small pieces of looking-glass, and paint all the square wood between them of a light and lively red; which, in the continual motion, will give such a reflection, that the birds will play about to admiration until they are taken.

Both this and the other stake are to be placed in the middle between the two nets, about two or three feet distance from each other; so that, in the falling of the nets, the cords may not touch or annoy them: neither must they stand one before or after another; the glass being kept in a continual motion, and the bird very often fluttering. Having placed your nets in this manner, as also your gigs and stakes, go to the further end of your long drawing-lines and stake lines; and, having placed yourself, lay the main drawing-line across your thigh, and, with your left, pull the stake-line to show the birds; and when you perceive them to play near and about your nets and stakes, then pull the net over with both hands, with a quick but not too hasty motion; for otherwise your sport will be spoiled.

See Plate CCCXLV. where A shows the bodies of the main net, and how they ought to be laid. B, the tail-lines, or the hinder-lines, staked to the ground. C, the fore-lines staked also to the ground. D, the bird-stake. E, the looking-glass stake. G, the line which draws the bird-stake. H, the line that draws the glass-stake. I, the drawing, double lines of the nets, which pulls them over. K, the stakes which stake down the four nether points of the nets and the two tail-lines. L, the stakes that stake down the fore-lines. M, the single line, with the wooden button to pull the net over with. N, the stake that stakes down the single line, and where the man should sit; and Q, the gig.

Net, *Neat*, in commerce, something pure, and unadulterated with any foreign mixture.

Thus, wines are said to be *net* when not falsified or balderdash; and coffee, rice, pepper, &c. are *net* when the filth and ordures are separated from them. See *NEAT*.

A diamond is said to be *net* when it has no stains or flaws; a crystal, when transparent throughout.

NET is also used for what remains after the tare has been taken out of the weight of any merchan-

dise; *i. e.* when it is weighed clear of all package. See *TARE*.

Thus we say, a barrel of cochineal weighs 450 pounds; the tare is 50 pounds, and there remains *net* 400 pounds.

NET-PRODUCE, a term used to express what any commodity has yielded, all tare and charges deducted.

The merchants sometimes use the Italian words *netto proceduto*, for net produce.

NETHERLANDS, anciently called *Belgia*, but since denominated *Low Countries* or *Netherlands*, from their low situation, are situated between 2° and 7° of east longitude, and between 50° and 53° 30' of north latitude: and are bounded by the German sea on the north, Germany on the east, by Lorrain and France on the south, and by another part of France and the British seas on the west; extending near 300 miles in length from north to south, and 200 miles in breadth from east to west. They consist of 17 provinces; 10 of which are called the *Austrian and French Netherlands*, and the other seven the *United Provinces*.

The greatest part of the Netherlands was conquered by the Romans; and that part which lies towards Gaul continued in their subjection till the decline of that empire; after which the Franks became masters of it; and, under the French monarchy, it was part of the kingdom of Metz or Austrasia.

Towards the end of the 15th century Maximilian of Austria, son of the Emperor Ferdinand III. acquired, by marrying the only daughter of the duke of Burgundy, the duchies of Brabant, Limburg, and Luxemburg; the counties of Flanders, Burgundy, Hainault, Holland, Zealand, and Namur; and the lordships of Friseland. Philip of Austria, son to Maximilian and Mary, married Jane the daughter of Ferdinand king of Arragon and of Isabella queen of Castile; by which means their son Charles inherited not only almost all Spain and the great countries then lately discovered in America, but also those noble provinces of the Netherlands, and was chosen emperor under the name of *Charles V.* Towards the latter end of the 1527, he added to his dominions the temporalities of the bishoprick of Utrecht on both sides of the Yssel; and Henry of Bavaria, being distressed through war with the duke of Guelderland, and tired with the continued rebellion of his own subjects, surrendered to the emperor the temporalities of his diocese, which was confirmed by the pope, and the states of the country. In 1536, Charles V. bought of Charles of Egmond the reversion of the duchy of Guelderland and of the county of Zutphen, in case that prince should die without issue. The same year the city of Groningen took the oath of allegiance, and submitted to Charles V. and in 1543 he put a garrison into the city of Cambray, and built a citadel there. Having thus united the 17 provinces, as it were in one body, he ordered that they should continue for ever under the same prince, without being ever separated or dismembered; for which purpose he published in November 1549, with the consent and at the request of the states of all the provinces, a perpetual and irrevocable edict or law, by which it was enacted, that in order to keep all those provinces together under one and the same prince,

Nether-lands.

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lands.

prince, the right of representation, with regard to the succession of a prince or princess, should take place for ever, both in a direct and collateral line, notwithstanding the common laws of some provinces to the contrary. Charles had even a mind to incorporate these provinces with the Germanic body, and to make of them a circle of the empire, under the title of the circle of Burgundy, in order thereby to engage princes of the empire to concern themselves for the preservation of those provinces. But the Netherlands, always jealous of their liberty, did not seem to like that incorporation; and when they were demanded to pay their share towards the expences of the empire, they refused it; whereupon the princes of Germany refused, in their turn, to take any part in the wars in Flanders, and looked upon those provinces as by no means belonging to the Germanic body.

Philip of Austria and his son Charles, who were born in the Netherlands, had for these provinces that natural affection which men used to have for their native country; and, knowing how jealous the inhabitants were of their liberty, and of the privileges granted to them by their former princes, they took great care to preserve them, and suffered willingly that the states, who were the guardians of the people's liberty and privileges, should in a manner share the supreme authority with them. Philip II. son to the Emperor Charles V. had not the same affection for the Netherlands, nor those generous sentiments which his father had endeavoured to inspire him with. Being born in Spain of a Portuguese woman, he had no regard but for his native country; and, when he removed out of the Netherlands, he left them to the weak government of a woman, to the proud and haughty spirit of Cardinal de Granville, and to the wild ambition of some lords of these provinces, who, availing themselves of the imprudent conduct and continual blunders of the council of Spain, found their private interest in the disturbances they could not fail to produce. Philip II. also, instead of the mild and moderate measures which his predecessors had successfully employed on many occasions, as best suiting the genius and temper of the people, had recourse to the most violent and cruel proceedings; which, far from curing the evil, served only to exasperate it the more and render it incurable. The Spaniards, whom he sent thither, being born and educated in an absolute monarchy, jealous of the liberties and envious of the riches of the people, broke through all their privileges, and used them almost after the same manner as they had done the inhabitants of their new and ill-gotten dominions in America. This treatment occasioned a general insurrection. The counts Hoorn, Egmont, and the prince of Orange, appearing at the head of it, and Luther's reformation gaining ground about the same time in the Netherlands, his disciples joined the malecontents: whereupon King Philip introduced a kind of inquisition in order to suppress them, and many thousands were put to death by that court, besides those that perished by the sword; for these persecutions and encroachments had occasioned a civil war, in which several battles were fought. The counts Hoorn and Egmont were taken and beheaded; but the prince of Orange, retiring into Holland, did, by the assistance of England and France,

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lands.

preserve Holland and some of the adjacent provinces, which entered into a treaty for their mutual defence at Utrecht in 1579, and they have ever since been styled the *United Provinces*; but the other provinces were reduced to the obedience of Spain by the duke of Alva and other Spanish generals. However, their ancient privileges were in a great measure restored; every province was allowed its great council or parliament, whose concurrence was required to the making of laws, and raising money for the government, though these assemblies were too often obliged to follow the dictates of the court.

The late Emperor Joseph II. endeavoured to deprive them even of the form of their free constitution; and he might very probably have succeeded, had he not attempted at the same time a reformation of the church. The Austrian Netherlands are wholly Catholic, and so bigotted to the Romish superstition, that though they had tamely submitted to many encroachments of the arch-ducal house on their civil right, no sooner did the monarch encroach upon the property of the holy mother-church than they resisted his authority, and claimed all their ancient privileges political and religious. The same attachment to their ancient faith and worship made them very lately contribute to expel from their territories the French whom they had invited to relieve them from the Austrian yoke. Thus her religious bigotry for once saved a free people from the iron rod of despotism on the one hand, and the cruelties of frantic democrats on the other. The provinces under the government of France were, till the late revolution, under the same severe arbitrary dominion as the other subjects of that crown, and they now experience the same miseries with the rest of the republic.

The Spaniards continued possessed of almost eight of these provinces, until the duke of Marlborough, general of the allies, gained the memorable victory of Ramillies. After which, Brussels the capital, and great part of these provinces, acknowledged Charles VI. (afterwards emperor) their sovereign; and his daughter, the late empress queen, remained possessed of them till the war that followed the death of her father, when the French made an entire conquest of them, except part of the province of Luxemburg; but they were restored by the peace of Aix-la-Chapelle in 1748, and the French retained only Artois, the Cambresis, part of Flanders, part of Hainault, and part of Luxemburg, of which they have had the dominion now upwards of eighty years.

The soil is generally fruitful, but differs in the several parts. The climate also differs in the several provinces; in those towards the south it does not differ much from that of England, though the seasons are more regular. In the northern provinces the winter is generally very sharp, and the summer sultry hot; but the extreme cold and excessive heat seldom continue above five or six weeks. The air is reckoned very wholesome, but is subject to thick fogs in winter, through the moistness of the country, which would be very noxious, were it not for the dry easterly winds, which, blowing off a long continent for two or three months in the year, clear the air, and occasion very sharp frosts in January and February; during which, the ports, rivers, and canals, are commonly shut.

Nethinims shut up. The face of the country is low and flat; for, except some small hills and a few rising grounds in Utrecht and Guelderland, and in the parts lying towards Germany, there is no hill to be seen in the whole 17 provinces. This is the reason that they have been called the Low Countries. French Flanders abounds in grain, vegetables, flax, and cattle, but is in want of wood.

For the *Dutch Netherlands*, see *UNITED PROVINCES*.

NETHINIMS, among the Jews, the posterity of the Gibeonites, who were condemned by Joshua to be hewers of wood and drawers of water for the house of God.

NETOPION, a name given by the ancients to a very fragrant and costly ointment, consisting of a great number of the finest spicy ingredients. Hippocrates, in his Treatise of the Diseases of Women, frequently prescribes the netopion in diseases of the uterus; and in other places he speaks of its being poured into the ear as a remedy for deafness; these compositions, by their attenuating qualities, dividing the viscous and thick humours. The word *netopion* is also sometimes used to express the *unguentum Aegyptiacum*, and sometimes simply for oil of almonds.

NETSCHER (Gaspard), an eminent painter, born at Prague in Bohemia in 1639. His father dying while he was an engineer in the Polish service, his mother was obliged, on account of her religion, suddenly to leave Prague with her three sons. When she had proceeded three leagues, she stopped at a castle; which being soon after besieged, two of her sons were starved to death; but she herself found means to escape out of the fortrefs by night, and to save her only remaining child. Carrying him in her arms, she reached Arnheim in Guelderland, where she found means to support herself, and breed up her son. At length a doctor of physic took young Netscher into his patronage, with the view of giving him an education proper for a physician: but Netscher's genius leading him to painting, he could not forbear scrawling out designs upon the paper on which he wrote his themes; and it being found impossible to conquer his fondness for drawing, he was sent to a glazier, who was the only person in the town that understood drawing. Netscher soon finding himself above receiving any farther assistance from his master, was sent to Deventer, to a painter named *Terburg*, who was an able artist and burgomaster of the town; and having acquired under him a great command of his pencil, went to Holland, where he worked a long time for the dealers in pictures, who paid him very little for his pieces, which they sold at a high price. Disgusted at this ungenerous treatment, he resolved to go to Rome; and for that purpose embarked on board a vessel bound for Bourdeaux. But his marrying in that city prevented his travelling into Italy: and therefore, returning into Holland, he settled at the Hague; where observing that portrait-painting was the most profitable, he applied himself solely to it, and acquired such reputation, that there is not a considerable family in Holland that has not some of his portraits; and besides, the greatest part of the foreign ministers could not think of quitting Holland without carrying with them one of Netscher's portraits, whence they are to be seen all over Europe. He died at the Hague, in 1684; leaving two sons,
N^o 241.

Theodore and Constantine Netscher, both of them good portrait-painters.

NETTINGS, in a ship, a sort of grates made of small ropes seized together with rope-yarn or twine, and fixed on the quarters and in the tops; they are sometimes stretched upon the ledges from the waste-trees to the roof-trees, from the top of the forecastle to the poop, and sometimes are laid in the waste of a ship to serve instead of gratings.

NETTLE, in botany, see *URTICA*.

Sea-NETTLE. See *MEDUSA* and *ANIMAL-Flower*.

NETTLE-Tree. See *CELTIS*.

NETTUNO, a handsome town of Italy, in the Campagna of Rome. It is but thinly peopled, though seated in a fertile soil. The inhabitants are almost all hunters. E. Long. 12. 57. N. Lat. 41. 30.

NEVA, a river at Petersburg, in Russia. The views upon the banks exhibit the most grand and lively scenes. The river is in most places broader than the Thames at London. It is deep, rapid, and transparent as crystal, and its banks are lined on each side with a continued range of handsome buildings. On the north side the fortrefs, the academy of sciences and that of arts are the most striking objects; on the opposite side are the imperial palace, the admiralty, the mansions of many Russian nobles, and the English line, so called because (a few houses excepted) the whole row is occupied by the English merchants. In front of these buildings, on the south side, is the quay, which stretches for three miles, except where it is interrupted by the admiralty; and the Neva, during the whole of that space, has been lately embanked at the expence of the empress by a wall, parapet, and pavement of hewn granite; a most elegant and durable monument of imperial munificence. There is a communication between the opposite sides of the river by a bridge of pontoons, which, when any thing is apprehended from the force of ice rushing down the stream, can be, and is generally indeed, removed. The great depth of the river, it appears, prevents the building of a stone-bridge; and if it could be built, there is no reason to suppose it could possibly resist the force of those vast shoals of ice which in the beginning of winter come down this rapid river. An attempt, however, has been made to remedy this inconvenience; and a Russian peasant has actually projected the plan of throwing a wooden bridge of one arch across it, which in its narrowest part is 980 feet in breadth. As we think this a matter of very considerable importance, as well as of curiosity, we shall give the following copious account of the plan and its author, in Mr Coxe's own words; who tells us that the artist had then executed a model 98 feet in length, which he saw and examined with considerable attention.

"The bridge is upon the same principle with that of Shaffhausen, excepting that the mechanism is more complicated, and that the road is not so level. I shall attempt to describe it by supposing it finished, as that will convey the best idea of the plan. The bridge is roofed at the top, and covered at the sides; it is formed by four frames of timber, two on each side, composed of various beams or trusses, which support the whole machine. The road is not, as is usual, carried over the top of the arch, but is suspended in the middle.

"The following proportions I noted down with the

Nettings
Neva.

Neva. the greatest exactness at the time when they were explained to me by the artist.

Length of the abutment on the north end,	658 feet.
Span of the arch,	980
Length of the abutment on the south end,	658
Length of the whole structure, including the abutments,	2296
The plane of the road upon its first ascent makes an angle of five degrees with the ordinary surface of the river.	
Mean level of the river to the top of the bridge in the centre,	168
Ditto to the bottom of the bridge in the centre,	126
Height of the bridge from the bottom to the top in the centre,	42
Height from the bottom of the bridge in the centre to the road,	7
Height from the bottom of ditto to the water,	84
Height from the water to the spring of the arch,	56

So that there is a difference of 35 feet between the road at the spring of the arch and the road at the centre; in other words, an ascent of 35 feet in half 980, or in the space of 490 feet, which is little more than eight-tenths of an inch to a foot. The bridge is broadest towards the sides, and diminishes towards the centre.

In the broadest part it is	168 feet.
In the centre or narrowest	42
The breadth of the road is	28

"The artist informed me, that to complete the bridge would require 49,650 iron nails, 12,908 large trees, 5,500 beams to strengthen them, and that it would cost 300,000 roubles, or L. 60,000. He speaks of this bold project with the usual warmth of genius; and is perfectly convinced that it would be practicable. I must own that I am of the same opinion, though I hazard it with great diffidence. What a noble effect would be produced by a bridge striking across the Neva, with an arch 980 feet wide, and towering 168 feet from the surface of the water? The description of such a bridge seems almost chimerical; and yet upon inspection of the model we become reconciled to the idea. But whether the execution of this stupendous work may be deemed possible or not, the model itself is worthy of attention, and reflects the highest honour on the inventive faculties of that unimproved genius. It is so compactly constructed, and of such uniform solidity, that it has supported 3540 pood, or 127,440 pounds, without having in the least

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swerved from its direction, which I am told is far more, in proportion to its size, than the bridge if completed would have occasion to sustain from the pressure of the carriages added to its own weight.

"The person who projected this plan is a common Russian peasant. This extraordinary genius was apprentice to a shopkeeper at Nishnei Novogorod: opposite to his dwelling was a wooden clock, which excited his curiosity. By repeated examinations he comprehended the internal structure, and without any assistance formed one exactly similar in its proportion and materials. His success in this first essay urged him to undertake the construction of metal clocks and watches. The empress, hearing of these wonderful exertions of his native genius, took him under her protection, and sent him to England; from whence, on account of the difficulties attending his ignorance of the language, he soon returned to Russia. I saw a repeating watch of his workmanship at the academy of sciences: it is about the bigness of an egg; in the inside is represented the tomb of our Saviour, with the stone at the entrance, and the centinels upon duty: suddenly the stone is removed, the centinels fall down, the angels appear, the women enter the sepulchre, and the same chant is heard which is performed on Easter-eve. These are trifling, although curious performances; but the very planning of the bridge was a most sublime conception. This person, whose name is *Kulibin*, bears the appearance of a Russian peasant; he has a long beard, and wears the common dress of the country. He receives a pension from the empress, and is encouraged to follow the bent of his mechanical genius (A)."

NEVEL, or NEBEL, in the Jewish antiquities, a kind of musical instrument. See NABLUM. Plate CCCXLIV.

NEVERS is the capital of the Nevernois in France, and government of Orleansois. It is situated E. longitude 3.15. N. latitude 46. 50. on the river Loire, which here receives the rivulet *Nievre*, from which this city derives its name. It is a place of great antiquity, supposed to be Cæsar's Noviodunum in *Æduis*, where he erected magazines for his armies. Francis I. made it a duchy and peerage in 1521, in favour of Francis of Cleve, to whom it came by marriage. It devolved afterwards to the house of Mantua, and then to the Palatine family, who in 1651 sold it to cardinal Mazarin. The cardinal obtained a title of duke and peer for his nephew Philip Mancini, in whose family it continued till the late revolution, though it is impossible, in the present unsettled state of France, to say whose property it may be now. The town is fortified with walls, defended with many high towers and deep ditches, and is the seat of a bishopric, suffragan of Sens, as likewise of a bailiwick and chamber of accounts.

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(A) We have given this detail in Mr Coxe's own words, as it appears to us to deserve attention on account of the greatness of the project, which would have excited admiration had it been attempted by one enlightened by science and liberal arts, much more when it comes through the humble medium of a Russian peasant. It was never executed, as we are just informed by a gentleman who left St Petersburg about the beginning of June 1793; but the model remains, and is still shown. The same gentleman (we quote his own words) adds, "that every mechanic thinks it practicable; and that the general belief is, that the empress would have built it, had she not found use for all her money in carrying on her warlike and diplomatic transactions with other courts."

Nevers, counts. There is a stone-bridge on the Loire, with twenty arches, a draw-bridge on each side, and towers to defend them. The cathedral is dedicated to St Cyr. There are eleven parishes in the town, and a great many religious houses. The Jesuits college near the gate des Ardeliers is a handsome structure. The palace of the dukes of Nevers has a large front between two great towers, with a court on one side and a garden on the other. Here it was that John Casimir king of Poland died the 16th of December 1672. Near this palace stands the convent of Cordeliers, who have a magnificent church, in which the tombs of duke John and Catharine of Bourbon on the right, and those of Lewis of Gonzaga duke of Nevers, and Henrietta of Cleves his wife, merit your attention.— This town is famous for its glass-manufacture and earthen-ware, and is said to contain about 8000 inhabitants.

In the centre of Nevers, on the summit of a hill, is built the palace of the ancient dukes. It appears to have been constructed in the sixteenth century, and, though beginning to exhibit marks of decay, is yet a model of the beauty and delicacy of the Gothic architecture. The apartments are hung with tapestry of 200 years old, which have an air of grotesque and rude magnificence. There is in one of the chambers a portrait of Madame de Montespan, who appears rising from a superb couch, the curtains of which are drawn back, and supported by Cupids. Her attitude is half voluptuous, half contemplative. She is dressed in a negligent dishabille, and her hair floats down over her shoulders and neck in waving ringlets. Her head rests on her left hand, and one of her feet is concealed by her robe; the other, which is naked to the mid-leg, and on which the painter, with great taste, has exhausted all his art, is placed on an embroidered cushion. Her slippers are thrown carelessly by.

NEUCHÂTEL, a tolerably handsome town of Switzerland, capital of a county of the same name. There are several ancient ruins near it, which show its former extent; and there are two large churches, besides a castle where the governor resides. The town contains about 3000 inhabitants. It is situated partly on a small plain between Mount Jura and the lake of Neuchâtel, which is 17 miles long and five broad; the side of the harbour is the usual walk of the inhabitants. Part of it too is built upon the side of the mountain; whence some of its streets are very steep. In this small place several public works have lately been executed, which Mr Coxe thinks are far beyond the revenues, or even the wants, of such a little state. Among these he instances a superb causeway and a town-house "built (says he) of such solid materials as if it was intended to survive to the most distant posterity, and to rival the duration of the much-famed Roman capitol." At the beginning of the present century, commerce was very little followed in this town, owing to an absurd opinion which prevailed among the inhabitants of its being disgraceful; but this prejudice is now extinguished, and the town in a much more flourishing situation than before. The chief article of exportation is wine, which is much esteemed; and manufactures of printed linens and cotton have been established with considerable success. The flourishing state of Neu-

châtel is principally owing to the benefactions of Mr Neuchâtel. David Pury, late banker of the court at Lisbon. He was born at Neuchâtel in 1709; but having received his education there, he quitted it in great poverty and repaired to Geneva, where he served his apprenticeship, but in what line is not mentioned. From Geneva he went to London, where he acted as clerk to a dealer in precious stones, and acquired great reputation by estimating the value of diamonds at sight. After a long residence in England he went to Lisbon, where he carried on a very extensive commerce; and having been appointed court-banker, his fortune rapidly increased. His generosity, however, kept pace with his wealth; and he not only remitted large sums to Neuchâtel while living, but left his country his heir when he died. His contributions in all are estimated by Mr Coxe at L. 200,000; a considerable part of which has been employed in constructing the public works already mentioned. Mr Coxe hints, that notwithstanding the superb edifices already mentioned, there are many conveniences still wanting to render Neuchâtel agreeable; the public walks, for instance, might be greatly improved, the streets, which are very dirty, might be kept clean, and a torrent which runs through the town, and frequently threatens it with inundations, might be turned. Encouragement ought also to be given to literature; for our author observes, that the inhabitants of Neuchâtel are much more ignorant than those of other parts in Switzerland, which no doubt is in a great measure owing to their having not a single seminary of learning which deserves the name in the place. It has a grand and little council: the first is composed of 40 persons, with two masters of the keys; the little council consists of 24 members, comprehending the mayor, who is president. These two councils assemble regularly every month. The ecclesiastics likewise assemble every month, to consult on affairs belonging to the church, and to fill up the places of ministers that die. They choose a dean every year, who is president of the general assemblies, which are called *cloffes*; and sometimes he is confirmed in this dignity. E. Long. 7. 10. N. Lat. 47. 5.

NEUCHÂTEL, a sovereign county of Switzerland, bounded on the west by the Franche Comte, on the north by the bishopric of Basle, and on the east and south by the cantons of Berne and Friburg. This principality of Neuchâtel and Vallengin extend from the lake of Neuchâtel to the borders of Franche Comte, being in length about 12 leagues, and six in breadth. The plain with the lower part of the mountains is occupied by the district of Neuchâtel, but Vallengin is totally inclosed by Jura. Parallel chains of these mountains run from east to west, forming several valleys in the most elevated parts. The lower grounds of this chain consist of arable lands and vineyards; the higher of large tracks of forest, which in many parts have been cleared and converted into pasture-grounds, intermixed with fields of barley and oats. The inhabitants are numerous, and remarkable for their genius, politeness, and active industry. It contains three cities, one town, 90 villages, and about 300 houses dispersed in the mountains. The inhabitants are all Protestants, except two Roman Catholic villages; and in 1529 they entered

Neuchâtel. tered into a strict alliance with the cantons of Berne, Friburg, Soleure, and Lucern. The air is healthy and temperate, but the soil not every where equally fertile: however, there are large vineyards, which produce white and red wine, which last is excellent. The pastures on the mountains feed a great number of all sorts of cattle; and there are plenty of deer in the forests; besides large trouts, and other good fish, in the lakes and rivers. The mildness of the government, and agreeable situation of the inhabitants in general in these districts, is evident from the great increase of population in the space of 32 years. In 1752 they contained only 28,017 subjects and 4318 aliens; but in 1784 the number was augmented to 31,576 subjects and 9704 aliens; being an increase of near a fourth part in that time. The facility with which the burghership of Neuchâtel is acquired, may also be accounted one of the means of augmenting its population; for between the years 1760 and 1770, the magistrates admitted 41 persons to this privilege; from 1770 to 1780, 46; from 1780 to 1785, 51; in all 138; many of whom had children before they purchased their burghership, and 38 of them were foreigners, either German, French, or Dutch.

The districts of Neuchâtel and Vallengin now make part of the Prussian dominions. It had its own counts for a long time; the last of whom dying in 1694 without issue, it came to Mary of Orleans duchess of Nemours, his only sister, who also died without issue in 1703. There were then 13 competitors, among whom was Frederick I. king of Prussia, who claimed as heir to the prince of Orange. His right was acknowledged by the states of the country in 1707; but in this part of his dominions the Prussian monarch is far from having such an absolute authority as in others. On the accession of Frederic I. some general articles were agreed on, by which the prerogatives of the prince and the rights of the people were settled. Disputes, however, occurred betwixt the king and his subjects, which were not thoroughly settled till the year 1768, when the general articles were not only renewed, but explained wherever their tenor had been mistaken, confirming also several privileges in favour of the people which had hitherto been equivocal or not duly observed. The most important of these general articles were, 1. The establishment of the reformed religion, and the toleration of no other, except in two places where it was already prevalent. 2. No civil or military office to be possessed by foreigners, that of governor only excepted. 3. All subjects have a right to enter into the service of a foreign prince not actually at war with the king as sovereign of Neuchâtel; the state may also continue neuter when the king is engaged in wars which do not concern the Helvetic body. 4. The proper administration of justice; for which the three estates of Neuchâtel and Vallengin shall be annually assembled. 5. The magistrates to hold their places during good behaviour; but of this certain persons appointed at Neuchâtel, and not the king, are to judge. 6. The sovereign, on his accession, shall take an oath to maintain the rights, liberties, and customs of the people, written and unwritten.

This last article is no less important than it is singular; for upon an unwritten custom one of their

most essential privileges depends; viz. that the sovereign shall be considered only as resident at Neuchâtel.

“Now (says Mr Coxe), this privilege, in conjunction with the third article just cited, forms the basis of their civil liberty. By the former, the prince, when absent, can only address his subjects through his governor and the council of state; and no subject can be tried out of the country, or otherwise than by judges appointed by the constitution: by the latter, should the king of Prussia be at war with all Germany, the people of Neuchâtel and Vallengin are by no means obliged to arm in his defence; but individuals may even serve against him, as long as the powers whom they serve are not engaged in any hostilities against their own country.” A remarkable instance of this last our author gives in the following anecdote. “When Henry duke of Longueville, and sovereign of Neuchâtel was, in 1650, sent to the castle of Vincennes, Felix de Mareval, captain of the Swiss guards, kept guard in his turn, though he was citizen of Neuchâtel, at the door of the prison where his sovereign was confined.”

The king confers nobility, names the principal officers of state, appoints the presidents of the courts of justice called *chatelains* and *mayors*; but his revenues scarcely amount to L. 5000 a-year. They arise from certain demesnes; from a small land-tax, the tythes of wine and corn, and a tenth part of the value of all immoveables. No subject pays any duty upon goods either exported or imported, except for foreign wines brought into the town itself.

Neuchâtel enjoys very considerable privileges, has the care of the police within its own district, and is governed by its own magistracy consisting of a great and little council. The three estates of the country form the supreme tribunal, and receive appeals from the inferior court of justice. They consist of 12 judges divided into three estates: the judges in the first and second division hold their places for life; but those in the third are chosen annually. The estates usually meet once a-year in the month of May, but are convoked extraordinarily upon particular occasions, and the town of Neuchâtel is always the place of meeting. They are not, however, the representatives of the people, nor do they possess any legislative authority. Properly speaking, they are the supreme court of judicature, which receives all appeals, and decides finally upon all causes, even those which relate to the sovereignty of the country, of which we have an example in the revolution of 1707. The ordinary administration of government is vested in the council of state, which superintends the general police, and is the medium by which the sovereign exercises his jurisdiction. The members are nominated by the king, and are not restricted to any number, but he is always considered as personally presiding in the assembly; and the president has no other powers than those of convoking the assembly, proposing the subjects of consideration, collecting the votes, and deciding when the voices are equal. The ordinances of this council are previously communicated to the *ministres* of Neuchâtel, who must certify that they contain nothing contrary to law. The *ministres* are a kind of committee from the council of the town, and are entrusted with the administration of the police. They con-

Neuchâtel. list of the two presidents of that council, four master-burgers taken from the little council, and the *banne-
ret* or guardian of the liberties of the people. The former six are changed every two years; and the banneret is chosen by the general assembly of the citizens, and continues in office during six years.

When the causes are decided in the month of May by the three estates, the four judges, who form the third estate, retire, and their place is supplied by the four ministres. The attorney-general then desires the members of the three estates to take into consideration whether it is necessary to frame any new laws. If a new ordinance is proposed, a declaration is drawn up and delivered to the council of state for their deliberation, whether it be contrary to the prerogatives of the prince or the rights of the subject; from thence it is communicated to the council of the town in order to be examined, whether it infringes the privileges of the citizens. If adopted by the council of state and the council of the town, it is proposed to the prince for his approbation or rejection: in the former case it is again publicly read before the three estates, and the governor or president declares the approbation of the sovereign. It is then promulgated, or passed into a law by the three estates. The people of Vallengin have always been consulted upon the framing a new law since the accession of the house of Brandenburg. For this purpose the three master-burgers of Vallengin examine, whether it contains any thing inconsistent with the franchises of that district; in which case they have the power of remonstrating to the governor in council. Every year, at the conclusion of the assembly of the estates of Neuchâtel, those of Vallengin, as constituting the supreme court of judicature for that country, meet at Vallengin, and decide finally all appeals from the inferior courts of justice. Both principalities are divided into a certain number of districts, each of which has its criminal court of justice. Every criminal is brought to trial immediately after he is arrested, and sentence is read to him in prison. Next morning he appears again before the judges, assembled in the open air; the former proceedings on the trial are read, and the judges once more deliver their opinion. In capital sentences the governor is immediately made acquainted with the circumstances of the case; and if he does not mitigate the sentence, it is put in execution without delay. Torture, though seldom used, is not entirely abolished in these districts. Great circumspection, however, is made use of in judicial proceedings, "which (says Mr Cœxe) may sometimes favour the escape of the criminal; but the few instances of atrocious crimes prove that this humane caution is no encouragement to transgressions, and is a strong presumption of the general good morals which prevail among the people. In a word, personal liberty is almost as tenderly and as securely protected by the laws of this country as by those of our own invaluable constitution. Thus the liberties of the people are as well and perhaps better secured, than even in the democratical cantons; for although the most despotic prince in Germany is sovereign, his power is exceedingly limited. Among the striking circumstances which characterise this government, must be mentioned the very liberal encouragement given to strangers who settle

in the country. They enjoy every privilege of trade and commerce; and in no state are fewer essential distinctions made between strangers and natives."

NEUFCHATTEAU, a town of France, in Lorraine, and capital of the chatellenie of Chatenoi. It is a handsome, populous, trading town; having an abbey of the nuns of St Clair, a commandery of Malta, and several convents of monks and nuns. It is seated in a bottom, in a soil fertile in corn, wine, and all the necessaries of life, on the river Mouzon. E. Long. 5. 45. N. Lat. 48. 20.

NEVIS, one of the Caribbee islands, lying about seven leagues north of Montserrat, and separated from St Christopher's by a narrow channel. It makes a beautiful appearance from the sea, being a large conical mountain covered with fine trees, of an easy ascent on every side, and entirely cultivated. The circumference is about 21 miles, with a considerable tract of level ground all around. The climate in the lower part is reckoned to be warmer than Barbadoes, but it is more temperate towards the summit. The soil is very fine in the lower part, but grows coarser as we ascend. The productions are nearly the same with those of St Christopher. There are three pretty good roads or bays, with small towns in their vicinity; Charles-town, Moreton-Bay, and Newcastle. This pleasant island was settled under the auspices of Sir Thomas Warner from St Christopher's. His successor, Governor Lake, was considered as the Solon of this little country, in which he disposed of every thing with such prudence, wisdom, and justice, as procured him an high reputation with the French as well as English. In the Dutch war they met with some disturbance from the French; but by being covered by an English squadron, the enemy were obliged to desist from their intended invasion, after a smart engagement in sight of the island. Sir William Stapleton sometimes resided here, and Sir Nathaniel Johnson constantly, at which time the inhabitants of Nevis were computed at 30,000. In the war immediately after the revolution, they exerted themselves gallantly, and had two regiments of 300 men each. In that of Queen Anne they behaved equally well, though they were less fortunate; for the French landing with a superior force, and having inveigled most of their slaves, they were forced to capitulate. About 4000 of these slaves the French carried away and sold to the Spaniards, to work in their mines. The parliament, after making due inquiry into the losses they had sustained, voted them about a third part of the sum in which they had suffered. These losses by war, an epidemic disease, and repeated hurricanes, exceedingly diminished the number of the people. They are now thought not to exceed 2000 or 3000 whites, and 6000 blacks. There is here a lieutenant-governor, with a council, and an assembly, which is composed of three members from each of the five parishes into which the island is divided. The commodities are cotton and sugar; and about 20 sail of ships are annually employed in this trade.

NEURADA, in botany: A genus of the decagynia order, belonging to the decandria class of plants; and in the natural method ranking under the 13th order, *Succulentæ*. The calyx is quinquepartite; there are five petals; the capsule inferior, decemlocular, deca-

Neuritics
||
Neuter.

mous, and aculeated. There is only one species, the *Procumbens*. The whole plant is white and woolly: it sends off numerous stalks in every direction, which lie flat on the ground: the leaves stand on short foot-stalks; they are of an oval shape, and plaited like those of the *ladies mantle*. It is a native of the warm climates, and found on dry parched grounds.

NEURITICS, in pharmacy, medicines useful in disorders of the nerves

NEUROGRAPHY, signifies a description of the nerves. See ANATOMY, n° 136.

NEUROPTERA. See ZOOLOGY.

NEUTER, a person indifferent, who has espoused neither party, and is neither friend nor foe.

A judge ought to be neuter in the causes he judges; in questions, where reason appears neuter, a man should ever incline to the side of the unhappy.

NEUTER, in grammar, denotes a sort of gender of nouns, which are neither masculine nor feminine. See GENDER.

The Latins have three kinds of genders, masculine, feminine, and neuter. In English, and other modern tongues, there is no such thing as neuter nouns. See NOUN.

Verbs-NEUTER, by some grammarians called *intransitive verbs*, are those which govern nothing, and that are neither active nor positive. See VERB.

When the action expressed by the verb has no object to fall upon, but the verb alone supplies the whole idea of the action; the verb is said to be *neuter*: as, I sleep, thou yawnest, he sneezes, we walk, ye run, they stand still.

Some divide verbs neuter into, 1. Such as do not signify any action, but a quality; as *albet*, "it is white;" or a situation, as *sedet*, "he sits;" or have some relation to place; as *adeft*, "he is present;" or to some other state or attribute, as *regnat*, "he rules;" &c. And, 2. Those that do signify actions, though those such as do not pass into any subject different from the actor; as to dine, to sup, to play, &c.

But this latter kind sometimes cease to be *neuter*, and commence active; especially in Greek and Latin, when a subject is given them: as, *vivere vitam. ambulare viam. pugnare pugnam*. Thus the old French poets say, *Soupirer son tourment*; the English, to sigh his woes, &c.

But this is observed only to obtain where something particular is to be expressed, not contained, in the verb: as, *vivere vitam beatam*, to live a happy life; *pugnare bonam pugnam*, to fight a good fight, &c.

According to the abbot de Dangeau, *verbs neuter* may be divided into *active* and *passive*; the first, those that form their tenses in English, by the auxiliary verb *to have*; in French, by *avoir*. The second, those that form them in English with the verb *to be*; in French *être*.—Thus, to sleep, to yawn, *dormir* and *eternuer*, are *neuters active*.—To come, and to arrive, are *neuters passive*.

NEUTRAL-Salts, among chemists, those compounded of an acid with any other substance capable of uniting with it and destroying its acidity. Those in which the acid is saturated with an earth or a metal are called *imperfect*, but those in which a pure alkali is employed are called *perfect*, *neutrals*.

NEUTRALITY, the state of a person or thing that is neuter, or that takes part with neither side.

NEW-ABBEY, situated near Kilcullen-bridge, in the county of Kildare, and province of Leinster, in Ireland. It was founded by Rowland Eustace, of a great and ancient family in this county; the tower is still standing, and some part of the abbey; the ruins of the rest have contributed to build several dwellings near it. In the inside Rowland Eustace and his lady lie buried; their figures, clothed in armour, are to be seen there. Near this is a handsome seat of the Carter family, on the opposite side of the river Liffey.

NEWARK, upon Trent, in the county of Nottingham, is a great thoroughfare in the York-road, 124 miles from London. It has bridges over the Trent, which forms an island here, by dividing itself into two streams two miles above the town, which meet again two miles below it. A magnificent castle was built here in the reign of King Stephen, which held out stoutly in the barons wars for King John, who died here, October 19th 1216; and it also stood out for king Charles I. to the last; but after he had put himself into the hands of the Scots army then before it, the governor by his order surrendered it, after which it was demolished.—It was situated near the river; the walls of the towers are very thick, and of a very great height; and were there no historical testimony, these remains are sufficient evidence that it was formerly of great importance. In the court before these ruins is a very fine bowling-green, and near it a manufactory of sackings. The town being subject to inundations from the river Trent, and often from that circumstance made impassable, a turnpike-road, at the instigation of a publican, was made about 20 years ago, so high as to be passed with safety in the greatest floods, by arches of brick being made in several places to carry off the water, constructed by Mr Smeaton, at the expence of L. 12,000. Near the town there is a bridge constructed for the same purpose, made mostly upon dry land, consisting of nine arches. It has a neat though small new street, and a market-place that is handsome, though not very spacious. Its church, which is reckoned one of the finest in the kingdom, was built by Henry VI. and has a lofty spire. It was incorporated by king Charles II. with a mayor and 12 aldermen.—The same king, in gratitude to the town for its loyalty to his father, gave it the privilege of sending members to parliament. It has a good trade in corn, cattle, wool, &c. and has a charity-school for 36 boys. Its market is on Wednesday; fairs on the Friday before Passion-Sunday, May 14th, Whit-Tuesday, August 12th, Nov. 1st, and Monday before December 11th. Here was an abbey of Augustine friars. A free-school was founded here, endowed with the lordship of Everton in this county; and the vicar of Newark, and the brethren of the Trinity-guild for the time being, who were then the chief governors of this town, were made perpetual trustees for this foundation. Many Roman urns and other antiquities have been found about this town, from whence it has been supposed that they had some town in the neighbourhood.

NEWBOROUGH, or NEWBURGH, in the Isle of Anglesey, North Wales, distant from London 254 miles, though but a small town, situated over against Caernarvon in North Wales, about 17 miles south-

west

Neutrality
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Newborough.

^{Newburg}
^{Newcastle.} west from Beaminster; is governed by a mayor, two bailiffs, and a recorder. Its Welch name is *Rhossir*, or *Rhosfair*. Its weekly markets, which are pretty well supplied with provisions, are kept on Tuesdays; and its annual fairs on the 22d of June, Aug. 10th and 21st, Sept. 25th, and Nov. 11th.

NEWBURG, the name of several towns of Germany, two of which are the chief towns of duchies of the same name; one in Bavaria, and the other in the Palatinate.

NEWBURY, a town in the county of Berks in England, 16 miles from Reading, and 56 from London, arose on the decay of Spinham-Land. Notwithstanding its name signifies *New-Borough*, it is as old almost as the Conquest. It made so much broad-cloth formerly, that in the reign of Henry VIII. here flourished John Winscomb, commonly called *Jack of Newbury*, one of the greatest clothiers that ever was in England, who kept 100 looms in his house; and in the expedition to Flowden-field against the Scots, marched with 100 of his own men, all armed and clothed at his own expence; and he built all the west part of the church. Also Mr Kenric, the son of a clothier here, though afterwards a merchant in London, left L. 4000 to the town, as well as L. 7500 to Reading, to encourage the woollen manufactory. It makes a great quantity of shalloons and druggets, but not near so much broad cloth now as formerly; yet it is a flourishing town, with spacious streets, and a large market-place, in which is the guild-hall. The church is a good one, of stone, supposed to have been built about 1640. It has seven sets of alms-houses. In the neighbourhood, on the banks of the Kennet, there is a stratum of petrified wood dug out for firing, when they frequently find trunks of large oaks yet undecayed, with petrified hazel nuts, fir-cones, &c. with the bones and horns of stags, antelopes, &c. tusks of boars, and heads of beavers. The river Kennet, which abounds with excellent trout, eels, and cray-fish, runs through the town; and here is plenty of all other provisions. It was made a corporation by Queen Elizabeth, and is governed by a mayor, high-steward, aldermen, &c. It sends a great quantity of malt to London, has good inns, and has a charity-school for 40 boys. Its market, which is well supplied with corn, is on Thursdays; and fairs on Holy-Thursday, July 5th, Aug. 24th, and Oct. 28th.

NEWCASTLE-Under-Line, a town in England, in the county of Stafford, on a branch of the Trent, is 15 miles north of Stafford, 33 south south-east of Warrington, and 149 from London; had a castle, now in ruins; and is so called from an older castle, which formerly stood two miles off, at Chesterton under Line. It was incorporated by King Henry I. and again by Queen Elizabeth and King Charles II. and is governed by a mayor, two justices, two bailiffs, and 24 common-council. The clothing-trade flourishes here; but its chief manufactory is hats, here being an incorporated company of felt-makers. The streets are broad and well paved, but most of the buildings low and thatched. The market is on Mondays; fairs on Easter-Monday, Whit-Monday, July 6th, first Monday in September, and November 6th, for cattle. It has also a great beast-market every other Monday. The corporation has a court, which holds

pleas for actions under L. 40. Its castle, of which ^{New castle.} there is little to be now seen, was built in the reign of Henry III. It had four churches formerly, which are now reduced to one, the town having suffered much in the barons wars. There are frequent horse-races in the neighbourhood, though it is in a manner surrounded with coal-pits; particularly one at Hamley-Green. It is softer than the cannel-coal, and is cut out in slices; but consumes so fast, that it is only fit for forges. There is the greatest quantity of stone-ware made near this place of any part of England; so that, one year with another, they are said to export 20,000l. worth of it.

NEWCASTLE, the capital of the county of Northumberland in England, 14 miles north of Durham, 94 north of York, 63 south by east of Berwick, 60 east of Carlisle, and 271 from London, stands at the end of the Picts wall, on the north side of the Tyne, over which it has a stately bridge into the bishopric of Durham, in which its suburb called *Gateside* is situated; for the liberties of Newcastle extend no farther than the great iron-gate upon the bridge, which has the arms of the bishop of Durham carved on the east side and those of Newcastle on the west side. It is admitted to have been a Roman station, though no evidence at present appears, except at Pandon-gate, whose superstructure is of different workmanship and model from any others of the town, the arches being circular. The carpenter's tower is also of Roman original. In the Saxons time it was called *Moncaester*, from the monks here, who all fled when it was depopulated by the Danes; and afterwards *New castle*, from a castle built here by William the Conqueror's son, Robert, in 1080, to defend the country against the Scots, whose kings had this town before the Norman conquest, and sometimes resided here.—Several monasteries and houses were built here soon after the castle; and it was greatly enlarged and enriched by a good trade to the coasts of Germany, and by the sale of its coal to other parts of England; for which, and for other merchandize, it is become the great emporium of the north of England, it being the neatest and largest town in those parts, next to York. In the reign of Edward I. it was burnt by the Scots; but a very rich burgher who was taken prisoner, soon ransomed himself for a good sum of money, and began the first fortifications of the place, which he extended from Sandgate to Pampeden, and thence to the Austin-friars gate; which the townsmen finished, and encompassed with stout walls, which extended two miles, wherein are seven gates and many turrets, with several casements bomb-proof. To which two other gates were added in more modern times, viz. Bridge-gate and Sand-gate: the wall between them was afterwards removed to open the quay. Edward III. granted the corporation the duties and customs of the town for seven years, to enable them to complete the fortification. It is a borough at least as ancient as king Richard II. who granted that a sword should be carried before the mayor; and king Henry VI. made it a town and county incorporate of itself, independent of Northumberland. Henry VII. built a monastery here for the Franciscans. Besides which, it had several religious foundations, several of which structures have been converted to companies halls and private residences.

Newcastle.

residences. In the reign of Henry VIII. this place is said to have exceeded in the strength and magnificence of its works all the cities of England, and most places in Europe. The town is governed by a mayor, 12 aldermen, a recorder, sheriff, town-clerk, a clerk of the chambers, two coroners, eight chamberlains, a sword-bearer, a water-bailiff, and seven serjeants at mace. Its situation, especially the most busy part of it towards the river, is very uneven, it being built on the declivity of a steep hill, and the houses very close. The castle overlooks the whole town. That part built by Robert was of great strength, and square, and surrounded by two walls; the square was 62 feet by 54, and the walls 13 feet thick, within which was a chapel. The outward fortifications are now defaced, and their site crowded with buildings. The tower remains entire, and situated on a lofty eminence, and its principal entrance is to the south. This castle belongs to the county, and makes no part of the liberties.— It is now the county prison, and in the great hall the judges hold the assizes. Here Baliol king of Scotland did homage to king Edward I. in 1292; as did Edward Baliol in 1334 to king Edward III. Here is a magnificent exchange and a customhouse; and the finest quay in England, except that at Yarmouth, being 700 yards long, it being far more spacious and longer than those at London or Bristol, though not equal to either for business. There is a handsome mansion-house for the mayor, who is allowed L. 1000 a-year for his table, besides a coach and barge. The old bridge was carried away in a flood, and the present was erected about 1775, of nine noble elliptic arches. With the old bridge 22 houses were thrown down, and six lives lost. It was originally built of wood; but having been destroyed by fire in 1248, was rebuilt of stone, and consisted of 12 arches, three of which on the north side were closed up, and served for cellars; this was again rebuilt about 1450, and was crowded with wooden buildings; but near the middle was a tower with an iron gate, used as a town prison. A strong building crossed the bridge, which was used as a magazine. On the south front was a statue of king Charles II. The water which destroyed this bridge, on November 11. 1771, was upwards of 12 feet above high-water mark in spring-tides.— On destroying the ruined peers of the old bridge to erect the present, by observations made, and medals found, part of it is supposed to have existed from the time of the Romans. It is computed that above 6000 keelmen are employed here, who have formed themselves into a friendly society; and, by their own contributions, built a noble hospital containing 50 chambers, for such of their fraternity as are poor, disabled, or past their labour; and it is supported by the contribution of those that are in health. The town is extremely populous; and, notwithstanding the multitude of those employed in and about the coal-pits, with which the town is in a manner surrounded, has abundance of poor; but it has also many wealthy inhabitants, and it is said they pay above L. 4000 a-year to their relief. It is observed, that this town has the greatest public revenue in its own right as a corporation, of any town in England, it being computed at no less than L. 8000 a-year. In 1774, the receipts of the corporation were L. 20,360:9:8;

Newcastle.

and their disbursements about L. 19,445. The number of inhabitants far exceeds 30,000. Here are four churches or chapels. That of St Nicholas is the mother-church, a curious fabric, built cathedral-wise by David king of Scots, 240 feet long, 75 broad, and proportionably high, with a tower steeple 194 feet in height, of Gothic architecture; also St Andrew's, St John's, and All-Saints, lately rebuilt on the site of the old structure, of a circular form. Here are also several meeting-houses, and four charity-schools for 300 children; a fine hall for the surgeons, and a large prison called *Newgate*; also an hospital for lunatics, another for the lying-in of married women, as well as a fund raised for the relief of those who are delivered at their own houses. Here is a well-endowed and large infirmary, and an assembly-room that attracts attention, containing every useful apartment, and a ball-room 93 feet by 40: The front is ornamented with six Ionic pillars, &c. In another part of the town is a new theatre. Here is a very neat set of baths. A free grammar-school was granted by James I. from an old foundation of St Mary's hospital, in the vestry-room of whose chapel is the election of the officers of the corporation. There were formerly several palaces in this city, viz. Pampeden-hall, Lumley place, Earl's place, Northumberland-house, Westmoreland-place, &c. The free-masons have lately erected an elegant hall, richly ornamented, to hold their lodge in, near High-friar chair, capable of holding above 4000 of that ancient fraternity. Here is an hospital for 39 decayed freemen and their widows; and another for three clergymen's widows and three merchants widows. The Maiden's-hospital, built in 1753, is endowed with L. 2400, for six maiden women and six poor men. Dr Thomlin, a prebendary of St Paul's, and rector of Whicham in the bishopric of Durham, lately gave a library of above 6000 valuable books to the corporation, and settled a rent-charge of L. 5 a year for ever for buying new ones; and Walter Blacket, Esq; one of its representatives in parliament, built a neat repository for them, and settled L. 25 a-year for ever on a librarian. The upper or north part of the town, inhabited by the politer sort of people, is much pleasanter than that part next the river, and has three level, well-built, and spacious streets. The river all the way up from Shields to Newcastle is broad, the channel safe, and the tide flows with a strong current to the town, and far beyond it. In the beginning of the late civil wars, this town was taken and plundered by the *Scotch fanatics*, who here sold their king, Charles I. for L. 200,000 in hand, and security for as much more. The glass-works are very curious, and have more business of the fine sort than most other places. Besides, it has a considerable manufacture of broad and narrow cloths, and several soap-boileries; and this place is famous for grindstones, for which there is such a demand, that scarce a ship stirs without them; from whence came the proverb, "That a Scotsman and a Newcastle grindstone travel all the world over." Ships fit for the coal-trade are built here to perfection, with great strength. Here is a considerable manufactory of hard-ware and wrought-iron, after the manner of that at Sheffield.— Its markets are on Tuesdays and Saturdays. Its fairs in August, which last nine days, and October 29th, which

Newcastle. which last nine days. By an act of Queen Mary, the price of the carriage of goods hither from London by waggons was settled at 2d. per lb. London alone is said to consume at least 766,887 chaldrons of its coal every year: but as for the fish vended in that city by the name of *Newcastle salmon*, it is more properly called *Berwick salmon*, the fresh salmon being taken near 50 miles farther, as far as the Tweed, and is brought on the backs of horses to Shields, where it is cured, pickled, and sent on board for London. It is worth remembering, that at the assizes here in 1743, two old men were subpoenaed hither as witnesses from a neighbouring village, viz. one 135 years of age, and his son 95, both hearty, and having their sight and hearing; and that in 1744, one Adam Turnbull died in this town aged 112, who had had four wives, the last of whom he had married when he was near 100 years old.

The annual amount of the revenue of customs at this port, which Mr Brand in his history of Newcastle states at 41,000 l. is now very considerably upwards of 70,000 l.

The coals carried out of it annually (on an average from 1785 to 1791) were nearly 448,000 Newcastle chaldrons; the weight of which is 1,187,200 tons.

The manufacture of earthen-ware is greatly increased, and carried on to great perfection in its neighbourhood, in seven potteries; and their produce exported hence to foreign parts, as well as to the different parts of this kingdom; some of which potteries constantly employ upwards of 100 persons, men, women and children.

New works of considerable extent for the manufacture of iron have been established; as also a very capital manufactory for white lead, milled lead, &c.

The trade with the West India islands is increasing, and may in time become very considerable; as the port has great advantages, in being able to supply on the cheapest terms many articles wanted in those islands; such as coals, grindstones, lime, bricks, tiles, iron-wares, &c.; and is most advantageously situated for the re-exportation of the West India produce to the ports on the Baltic, to Germany, the United Provinces, Flanders, and part of France; and moreover, the risk of navigation, and the rate of insurance, not being greater than between those islands and Liverpool, and some other ports on the western coast of this kingdom.

The town of Newcastle is daily increasing in its population and opulence; and it would be well if it could not be added, in luxury, the almost necessary consequence of riches: but it should not be omitted, that it is noted for hospitality and good living.

Great improvements have been made in the town, by opening new streets, and paving the principal ones, in the same manner as in London. It cannot be said that it is well lighted, the few lamps scattered here and there serving but to make darkness visible; nor have the orders repeatedly given by the magistrates for cleaning the streets been attended with the full desired effect.

To the list of public edifices of modern erection, and mentioned above, viz. the grand assembly rooms, and the elegant theatre, which were built by subscrip-

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tion, and the superb parish-church of All Saints, Newcastle built at a very great expence by the parishioners, may be added a commodious riding-house, built also by subscription.

New-Forest.

NEWCASTLE, a borough town of Ireland, in the county of Dublin, and province of Leinster, which returns two members to parliament, and holds two fairs, 9th of May and 8th of October.

NEWCASTLE is also the name of a handsome town in the county of Limerick and province of Munster, on the high road to Kerry, 114 miles from Dublin. Here was a religious house possessed by the knights templars. It is said, they used some barbarous customs which greatly disgusted the Irish, who, watching a favourable opportunity, attacked a number of the knights riding out together and put them to death; the place is still remembered where their remains were interred. This order was suppressed in the famous council of Vienna, 22d of March 1312. Newcastle consists of a large square where markets and fairs are held; on the northern side stands a market-house, with an assembly-room; on the south side is the church, which is the neatest in the county, and it was finished in 1777 at the sole expence of Lord Courtenay. It stands close to the walls and fortifications of the knights templars, of which one of the castles is fitted up for Lord Courtenay's agent.

NEWCASTLE, a small town in America, 35 miles below Philadelphia, on the west bank of Delaware river. It was first settled by the Swedes about the year 1627, and called *Stockholm*. It was afterwards taken by the Dutch, and called *New Amsterdam*. When it fell into the hands of the English, it was called by its present name. It contains about 60 houses, which have the aspect of decay, and was formerly the seat of government. This is the first town that was settled on Delaware river.

NEWCASTLE (Duke of). See CAVENDISH.

NEW ENGLAND. See ENGLAND (New.)

NEW-Forest of Hampshire in England, is a tract of at least 40 miles in compass, which had many populous towns and villages, and 36 mother-churches, till it was destroyed and turned into a forest by William the Conqueror. There are nine walks in it; and to every one a keeper, under a lord-warden, besides two rangers, and a bow-bearer. As this large tract lay many ages open and exposed to invasions from foreigners, King Henry VIII. built some castles in it; and it has now several pretty towns and villages. It is situated in that part of Hampshire which is bounded on the east by Southampton river, and on the south by the British Channel. It possesses advantages of situation, with respect to the convenience of water-carriage and nearness to the dock-yards, superior to every other forest, having in its neighbourhood several ports and places of shelter for shipping timber, among which Lymington is at the distance of only two miles, Bewley about half a mile, and Redbridge three or four miles from the Forest; and the navigation to Portsmouth, the most considerable dock-yard in this kingdom, is only about 30 miles from the nearest of those places. This is the only forest belonging to the crown of which the origin is known. Domesday-book contains the most distinct account of its afforestation by William the Conqueror: the contents of every

New Fo-
rest.

every field, farm, or estate afforested, in hides, carucates, or virgates, by which the extent of land was then computed, together with the names of the hundreds and villages, and of the former proprietors (which are for the most part Saxon), the rent or yearly value of each possession, and the tax which had been paid for it to the crown during the reign of Edward the Confessor, before the inhabitants were expelled, and that part of the country laid waste, are all to be found in that most curious and venerable record, *Wishing to discover the original extent of the forest, we extracted, for our own information, all that relates to it in that ancient survey. The extract is far too voluminous for insertion. The names of many of the places having been changed since that time, it is difficult to ascertain with precision what were then the limits of the forest. The oldest perambulation we have met with is among the Pleas of the Forest, in the eighth year of King Edward I. preserved in the Chapter-house at Westminster. The boundaries there described include all the country from Southampton river on the east to the Avon on the west, following the sea-coast as far as the southern boundary between those rivers, and extending northwards as far as North Chadeford, or North Charford, on the west, and to Wade and Orebrugg, or Owerbridge, on the east; and the greatest part, if not the whole, of that extensive district, is mentioned in Domesday-book to be the forest belonging to the crown. Another perambulation was however made in the 29th of the same king, which leaves out a great part of the country contained within the former. This perambulation, which is preserved in the tower of London, confines the forest to limits which, as far as we can trace them, appear to have been followed in the 22d year of Charles II. when the forest was again perambulated. By the *Charta de Foresta*, all lands not belonging to the crown which had been afforested by Henry I. Richard I. or King John, were to be disafforested; but as no provision was made for the reduction of the more ancient afforestations, it is easy to account for the great diminution of this forest in the reign of Edward I. who was not a prince likely to submit to any encroachment on his rights. The perambulation of the 22d of Charles II. is the last which we find on record: it contains the present legal bounds of the forest, and was given to the surveyors as their guide, in taking the plan which they have made lately by direction. From that plan, with the approbation of the lords commissioners of his majesty's treasury, an engraving was made. According to the last mentioned perambulation and the plan, the forest extends from Godshill on the north-west to the sea on the south-east, about 20 miles; and from Hardley on the east to Ringwood on the west, about 15 miles; and contains within those limits about 92,365 acres statute measure. The whole of that quantity, however, is not forest-land, or now the property of the crown: there are several manors and other considerable freehold estates within the perambulation, belonging to individuals, to the amount of about 24,797 acres; about 625 acres are copyhold or customary lands belonging to his majesty's manor of Lyndhurst; about 1004 acres are leasehold under the crown, granted for certain terms of years, and forming*

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part of the demised land-revenue, under the management of the surveyor-general of crown-lands; about 901 acres are purprestures or encroachments on the forest; about 1193 acres more are inclosed lands held by the master-keepers and groom-keepers, with their respective lodges; and the remainder, being about 63,845 acres, are woods and waste lands of the forest. To perpetuate the spot where William Rufus was killed by the glance of an arrow shot at a stag, a triangular stone was erected in 1745. George III. visited this spot in 1789. In August 1782, a curious ancient golden cross was found here by a labouring man digging turf. It weighed above an ounce of gold, and had on one side an engraving of our Saviour, and on the other, the ladder, spear, nails, and other emblems of his sufferings.

NEW-Holland. See HOLLAND (New.)

NEW-York. See YORK (New.)

NEW-Zealand. See ZEALAND (New.)

NEW-Years Gifts. Presents made on the first day of the new year. Nonius Marcellus refers the origin of this custom among the Romans to Tatius king of the Sabines, who reigned at Rome conjointly with Romulus, and who having considered as a good omen a present of some branches cut in a wood consecrated to *Strenia*, the goddess of strength, which he received on the first day of the new year, authorised this custom afterwards, and gave to these persons the name of *strenæ*. However this may be, the Romans on that day celebrated a festival in honour of Janus, and paid their respects at the same time to Juno; but they did not pass it in idleness, lest they should become indolent during the rest of the year. They sent presents to one another of figs, dates, honey, &c. to show their friends that they wished for a happy and agreeable life. Clients, that is to say, those who were under the protection of the great, carried presents of this kind to their patrons, adding to them a small piece of silver. Under Augustus, the senate, the knights, and the people, presented such gifts to him, and in his absence deposited them in the capitol. Of the succeeding princes some adopted this custom and others abolished it; but it always continued among the people. The early Christians condemned it, because it appeared to be a relique of Paganism and a species of superstition; but when it began to have no other object than that of being a mark of veneration and esteem, the church ceased to disapprove of it.

NEWEL, in architecture, is the upright post which a pair of winding stairs turn about; this is properly a cylinder of stone, which bears on the ground, and is formed by the end of the steps of the winding stairs.

NEWFIDLER-SEA, a lake in Hungary, 17 miles in length and 6 in breadth

NEWFOUNDLAND, a large island of North America, belonging to Great Britain, lying between 46. 50. and 51. 30. N. Lat. and between 53. 30. and 58. 20. W. Long. from London. The form is that of an irregular triangle, the base or south side being 80 leagues in extent; the east side is the longest; and the whole circumference about 150 leagues. It is bounded on the north by the Straits of Belleisle, which separate it from Labrador; on the east and

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Newfound-
land.

south it hath the Atlantic Ocean, and on the west the Gulph of St Laurence. The climate is rather severe; and the soil, at least on the sea-coast, which is all that we know of it, is poor and barren. A few kitchen vegetables with strawberries and raspberries are all its produce. The country within land is mountainous, and abounds with timber; there are several rivers which are plentifully stored with various sorts of fish, abundance of deep bays, and many good ports. St John's and Placentia are the two principal settlements, and at each of these there is a fort; the number of people who remain here in the winter hath been computed at 4000. The French, by the treaty of Utrecht, were permitted to fish from Cape Bonavista on the east side round the north of the island to Point Rich on the west; and by the treaty of Paris, they are allowed the isles of St Pierre and Miquelon, upon which they are to dry their fish, but not to erect fortifications of any kind.

The great importance of this place arises from its fishery, which is in part carried on by the inhabitants at the several harbours, which are about 20 in number, who take vast quantities of cod near the coast, which they bring in and cure at their leisure, in order to have it ready for the ships when they arrive. But the great and extensive fishery is on the banks at some distance from the island. The great bank lies 20 leagues from the nearest point of land from the latitude 41° to 49° , stretching 300 miles in length and 75 in breadth. To the east of this lies the False Bank; the next is styled *Vert* or *the Green Bank*, about 240 miles long, and 120 over; then Banquero, about the same size; the shoals of Sand Island, Whale Bank, and the Bank of St Peter's, with several others of less note, all abounding with fish.

The cod are caught only by a hook; and an expert fisher will take from 150 to 300 and upwards in a day; for the fish never bite in the night, and the labour is very great. The season is from May to October, in the height of which there are from 500 to 700 sail upon the banks at a time. The fish caught in the spring-months are best; they are cured in very different ways. Some are styled *white fish*, others *mud fish*, which are flowed and salted in the hold, and will not keep long; but the best and most valuable are the dried cod. The quantity taken is prodigious; yet in some seasons and in different places varies considerably, as the fish frequently change their stations. The *fishing-ships*, as they are called, lie upon the banks, with the help of their boats take and cure their own fish, and as soon as they are full sail for a market. The sack-ships proceed directly to the island, where they purchase fish from the inhabitants either by barter or bills of exchange. The principal markets for cod are Spain, Portugal, Italy, and the West Indies. The value of this fishery is computed at some hundred thousand pounds annually; employing, besides several hundred ships, some thousands of seamen, and affording a maintenance to a number of tradesmen of different occupations, by which many large towns on the west side of England accumulate much wealth, and at the same time contribute in many respects to the benefit of the public.

The great utility of this fishery was very early seen, and very vigorously pursued; for in the beginning of the reign of king James I. we had two hun-

dred and fifty sail employed therein. It is computed, that three quintals of wet fish make one quintal of dried cod. Besides, the livers of every hundred quintals make a hoghead of oil; and exclusive of these, there are many lesser advantages that go in diminution of the expence. The fishery, as we have said above, produces differently in different seasons; but it is judged to be a very good one when it produces 300,000 quintals of fish and 3000 barrels of oil, both equally saleable and valuable commodities. As every ship carries twelve, and each of their boats eight men, and as these return home in six months, there cannot be a more noble nursery for seamen. The artificers and traders employed in building, victualling, and repairing these vessels, are very numerous in the respective ports from which they sail. These circumstances justify the particular attention paid by government to this branch of the public service; in respect to which, that they may be well informed, an annual and very distinct account, by which the whole is seen at one view, is delivered by the proper officer to the governor of Newfoundland, that is, to the commodore of his majesty's squadron. Mr Pennant, in the appendix to his *Arctic Zoology*, gives us, from what appears to be very good authority, the following account of this island.

"Within the circuit of 60 miles of the southern part, the country is hilly, but not mountainous. The hills increase in height as they recede from the sea; their course is irregular, not forming a chain of hills, but rise and fall abruptly. The coasts are high, and the shores most remarkably bold. The same may be said of almost every part of this vast island. The country is much wooded, and the hills (such which have not flat tops to admit the rain to stagnate on them) are clothed with birch, with hazel, spruce, fir, and pine, all small; which is chiefly owing to the inhabitants taking off the bark to cover the fish stages. This peninsula is so indented by the fine and deep bays of Placentia, St Mary, Conception, and Trinity, that it may be easily penetrated in all parts, which is done for the sake of fowling, or the procuring of spars for masts, oars, &c. The island is on all sides more or less pierced with deep bays, which peninsulate it in many places by isthmuses most remarkably narrow.—The mountains on the south-west side, near the sea, are very high, and terminate in lofty headlands. Such are Chapeau rouge, a most remarkably high promontory, Cape St Mary's, and Cape le Hune. Such in general is the formation of the island; on the north-east, most of the hill in the interior part of the country terminate pyramidally, but form no chain. The interior parts of the country consist chiefly of morasses, or dry barren hammocks, or level land, with frequent lakes or ponds, and in some places covered with stunted black spruce. The rivers of Newfoundland are unfit for navigation, but they are of use in floating down the wood with the summer floods. Still the rivers and the brooks are excellent guides for the hunters of beavers and other animals, to penetrate up the country, which as yet has never been done deeper than 30 miles. Near the brooks it is that timber is commonly met with, but seldom above three or four miles inland, and in valleys; the hills in the northern district being naked and barren.

"In some parts of Newfoundland there is timber sufficiently

Newfound-
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Newfound-
land.

sufficiently large for the building of merchant ships: the hulk is made of juniper, and the pine furnishes masts and yards; but as yet none has been found large enough for a mast for a large cutter. The fishery is divided into two seasons; that on the shore, or the shore season, commences about the 20th of April, and ends about the 10th of October; the boats fish in from four to 20 fathoms water. The most important, the bank-fishing season, begins the 10th of May, and continues till the last of September, and carried on in 30 to 45 fathoms depth of water. Banking vessels have sailed from St John's to the bank as early as the 12th of April. At first they use pork or birds for a bait; but as they catch fish, they supply themselves with a shell fish called clams, which is found in the belly of the cod. The next bait is the lobster; after that the herring and the launce, which last till June, when the capelan comes on the coast, and is another bait. In August the squid comes into use, and finally the herring again. The greatest number of cod-fish taken by a single fisherman in the season has been 12,000, but the average is 7000. The largest fish which has been taken was four feet three inches long, and weighed 46 pounds. A banking vessel of 10,000 fish ought to be filled in three weeks, and so in proportion; and 80 quintals (112 lb. each) for a boat in the same time.

"In 1785, 541 English vessels fished on the bank, a number exceeding that of the French. A heap of dried fish, 20 feet long and ten wide, and four deep, contains 300 quintals. Such an heap settles, in the course of 48 hours after it is made, about $\frac{1}{12}$. An extraordinary splitter will split five quintals of fish in an hour. The average in that time is two. There is no fishing during winter, on account of the inclemency of the season. It is supposed that the fish in a great measure quit the banks before that time, as in general they are very scarce when the fishing vessels go upon the banks early in the spring.

"There are a few small towns on the coasts, which have gardens sown with English pulse; but many of the inhabitants quit the country in winter.

"An admiral or some sea officer is governor of Newfoundland. He sails from England in May, and returns by the 30th of November."

NEWMARKET, in Cambridgeshire, 13 miles from Cambridge, 13 from St Edmundsbury, and 60 from London, is a town with one long street, the north side in Suffolk, the south side in Cambridgeshire. It is a healthy place, and a great thoroughfare in the road from London to Norfolk; but stands mostly by the horse-races every year in April and October, here being the finest course in England; on which there is a house for the king when he comes to the races, which was built by Charles II. The king gives a plate or two every year, besides those given by the nobility; and wagers are laid upon the horses, which are seldom under 500 l. and often above 1000 l. Here are two coffeehouses, at which, every night and morning during the races, there is gaming, as there is also at the houses of the nobility and gentry. Here are also cock-matches. Here is a little chapel, which is a chapel of ease to the mother-church at Ditton; and another in the Suffolk side, which is parochial. The town was burnt in 1683, but soon re-

built. Here are two charity-schools, one for 20 boys, another for 20 girls, supported by 50 l. a-year, first settled by Queen Anne. Here is a market on Tuesdays and Thursdays, and fairs on October 28. and Whitsun-Tuesday.

NEWROSS, a borough town in the county of Wexford, and province of Leinster, in Ireland, 67 miles from Dublin. It returns two members to parliament; the patronage is in the families of Tottenham and Leigh. This town was formerly walled, and some of the gates still remain. It lies on the river Barrow, which is here very deep, and ships of burden can come up to the quay even when the tide is out. The church is large, but the custom-house and quay are both small, and sometimes overflowed many feet. It is one of the staple ports for exporting wool, yet its trade is but inconsiderable; beef and butter are the principal articles exported. Here is a barrack for a troop of horse, and a good ferry into the county of Kilkenny. Near this town is a charter-school. It is also a post town, and gives title of earl to the family of Gore. It was formerly fortified, and adorned with many religious houses, among which was a crouched friary, built on the summit of a hill in the town; but one of the friars having killed a principal inhabitant, the whole body of the people arose, put the friars to death, and totally destroyed the friary; on the site of which the monastery of St Saviour, for conventual Franciscans, was afterwards erected by Sir John Devereux; and the east end of this last building is now the parish-church. A friary for Eremites, following the rule of St Augustine, was also founded here in the reign of Edward III.

NEWS-PAPERS, periodical publications, daily, weekly, &c. for the purpose of communicating to the world every thing of importance, whether political or literary, &c. which is going on. They have tended much to the dissemination of learning, and have served many other valuable purposes; and while they are carried on with candour, impartiality, and ability, they are unquestionably a great national benefit. When this, however, is not the case, and it often happens, they disgrace their authors, and are highly injurious to the public. They were first published in England, August 22, 1642. *Journal des Savans*, a French paper, was first published in 1665, though one was printed in England, under the title of the *Public Intelligencer*, by Sir Roger L'Estrange, 1663, which he dropped, on the publication of the first London Gazette. Newspapers and pamphlets were prohibited by royal proclamation 1680. Though at the revolution prohibitions of this kind were done away, and the press set at liberty, yet newspapers were afterwards made objects of taxation, and for this purpose were first stamped 1713. The number of them, however, gradually increased; and there were printed in the whole kingdom during the years 1775, 12,680,000; 1776, 12,830,000; 1777, 13,150,642; 1778, 13,240,059; 1779, 14,106,842; 1780, 14,217,371; 1781, 14,397,620; 1782, 15,272,519. They are now still more numerous.

NEW-STYLE, first used in England in 1753, was introduced into the western world by Pope Gregory XIII. See CHRONOLOGY, n^o 24.

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New-style.

Newton,
Newton.

NEWT, or EFT, in Zoology, the common lizard. See LACERTA.

NEWTON (Sir Isaac), one of the greatest philosophers and mathematicians the world has ever produced, was the only child of Mr John Newton of Coleworth, not far from Grantham in Lincolnshire, who had an estate of about 120 l. *per annum*, which he kept in his own hands. He was born at that place on Christmas day 1642. His father dying when he was young, his mother's brother, a clergyman of the name of *Ayscough*, or *Aiskew*, who lived near her, and directed all her affairs after the death of Mr Newton, put her son to school at Grantham. When he had finished his school learning, his mother took him home, intending, as she had no other child, to have the pleasure of his company; and that he, as his father had done, should occupy his own estate. But his uncle happening to find him in a hay-loft at Grantham working a mathematical problem, and having otherwise observed the boy's mind to be uncommonly bent upon learning, he prevailed upon her to part with him; and she sent him to Trinity College in Cambridge, where her brother, having himself been a member of it, had still many friends. Isaac was soon taken notice of by Dr Isaac Barrow; who, observing his bright genius, contracted a great friendship for him. M. de Fontenelle tells us, "That in learning mathematics he did not study Euclid, who seemed to him too plain and simple, and unworthy of taking up his time. He understood him almost before he read him; and a cast of his eye upon the contents of his theorems was sufficient to make him master of them. He advanced at once to the geometry of Des Cartes, Kepler's optics, &c. It is certain, that he had made his great discoveries in geometry, and laid the foundation of his two famous works the *Principia* and the *Optics*, by the time he was 24 years of age."

In 1664, he took the degree of bachelor of arts; and in 1668 that of master, being elected the year before, fellow of his college. He had before this time discovered the method of fluxions; and in 1669 he was chosen professor of mathematics in the university of Cambridge, upon the resignation of Dr Barrow. The same year, and the two following, he read a course of optical lectures in Latin, in the public schools of the university; an English translation of which was printed at London in 1728, in 8vo, as was the Latin original the next year in 4to. From the year 1671 to 1679, he held a correspondence by letters with Mr Henry Oldenburg secretary of the royal society, and Mr John Collins fellow of that society; which letters contain a variety of curious observations.

Concerning the origin of his discoveries, we are told, that as he sat alone in a garden, the falling of some apples from a tree led him into a speculation on the power of gravity; that as this power is not diminished at the remotest distance from the centre of the earth to which we can rise, it appeared to him reasonable to conclude, that it must extend much farther than was usually thought; and pursuing this speculation, by comparing the periods of the several planets with their distances from the sun, he found, that if any power like gravity held them in their courses, its strength must decrease in the duplicate proportion of the increase of distance. This inquiry was dropped; but re-

sumed again, and gave rise to his writing the treatise *Newton* which he published in 1687, under the name of *Mathematical Principles of Natural Philosophy*; a work looked upon as the production of a celestial intelligence rather than of a man. The very same year in which this great work was published, the university of Cambridge was attacked by king James II. when Mr Newton was one of its most zealous defenders, and was accordingly nominated one of the delegates of that university to the high-commission court; and the next year he was chosen one of their members for the convention-parliament, in which he sat till it was dissolved. In 1696, Mr Montague, then chancellor of the exchequer, and afterwards earl of Halifax, obtained for him of the king the office of warden of the mint; in which employment he was of signal service, when the money was called in to be recoined. Three years after, he was appointed master of the mint; a place of very considerable profit, which he held till his death. In 1699, he was elected one of the members of the royal academy of sciences at Paris. In 1701, he was a second time chosen member of parliament for the university of Cambridge. In 1704, he published his *Optics*; which is a piece of philosophy so new, that the science may be considered as entirely indebted to our author. In 1705, he was knighted by queen Anne. In 1707, he published his *Arithmetica Universalis*. In 1711, his *Analysis per Quantitatum Series, Fluxiones et Differentias*, &c. was published by William Jones, Esq. In 1712, several letters of his were published in the *Commercium Epistolicum*. In the reign of George I. he was better known at court than before. The princess of Wales, afterwards queen-consort of England, used frequently to propose questions to him, and to declare that she thought herself happy to live at the same time with him, and have the pleasure and advantage of his conversation. He had written a treatise of ancient chronology, which he did not think of publishing; but the princess desired an abstract, which she would never part with. However, a copy of it stole abroad, and was carried into France; where it was translated and printed, with some observations, which were afterwards answered by Sir Isaac. But, in 1728, the Chronology itself was published at London in quarto; and was attacked by several persons, and as zealously defended by Sir Isaac's friends. The main design of it was to find out, from some tracts of the most ancient Greek astronomy, what was the position of the colures with respect to the fixed stars, in the time of Chiron the centaur. As it is now known that these stars have a motion in longitude of one degree in 72 years, if it is once known thro' what fixed stars the colure passed in Chiron's time, by taking the distance of these stars from those through which it now passes, we might determine what number of years is elapsed since Chiron's time. As Chiron was one of the Argonauts, this would fix the time of that famous expedition, and consequently that of the Trojan war; the two great events upon which all the ancient chronology depends. Sir Isaac places them 500 years nearer the birth of Christ than other chronologers generally do.

This great man had all along enjoyed a settled and equal state of health to the age of 80, when he began to be afflicted with an incontinence of urine.

Newton. urine. However, for the five following years, he had great intervals of ease, which he procured by the observance of a strict regimen. It was then believed that he certainly had the stone; and when the paroxysms were so violent, that large drops of sweat ran down his face, he never uttered the least complaint, or expressed the smallest degree of impatience; but, as soon as he had a moment's ease, would smile and talk with his usual cheerfulness. Till then he always read and wrote several hours in a day. He had the perfect use of all his senses and understanding till the day before he died, which was on the 20th of March 1726-7, in the 85th year of his age. — He lay in state in the Jerusalem chamber at Westminster, and on the 28th of March his body was conveyed into Westminster abbey; the pall being supported by the lord chancellor, the dukes of Montrose and Roxburgh, and the earls of Pembroke, Suffex, and Macclesfield. The bishop of Rochester read the funeral office, being attended by all the clergy of the church. The corpse was interred just at the entrance into the choir, where a noble monument is erected to his memory.

Sir Isaac was of a middling stature, and in the latter part of his life somewhat inclined to be fat. His countenance was pleasing, and at the same time venerable. He never made use of spectacles, and lost but one tooth during his whole life.

His temper is said to have been so equal and mild, that no accident could disturb it. Of this the following remarkable instance is related. Sir Isaac had a favourite little dog, which he called *Diamond*; and being one day called out of his study into the next room, *Diamond* was left behind. When Sir Isaac returned, having been absent but a few minutes, he had the mortification to find, that *Diamond* having thrown down a lighted candle among some papers, the nearly finished labour of many years was in flames, and almost consumed to ashes. This loss, as Sir Isaac was then very far advanced in years, was irretrievable; yet, without once striking the dog, he only rebuked him with this exclamation, "Oh! *Diamond*! *Diamond*! thou little knowest the mischief thou hast done!"

He was a great lover of peace; and would rather have chosen to remain in obscurity than to have the calm of life ruffled by those storms and disputes which genius and learning always draw upon those that are peculiarly eminent for them. In contemplating his genius it presently becomes a doubt, which of these endowments had the greatest share, sagacity, penetration, strength, or diligence: and, after all, the mark that seems most to distinguish it is, that he himself made the justest estimation of it, declaring, that, if he had done the world any service, it was due to nothing but industry and patient thought; that he kept the subject under consideration constantly before him, and waited till the first dawning opened gradually, by little and little, into a full and clear light. It is said, that when he had any mathematical problems or solutions in his mind, he would never quit the subject on any account. Dinner has been often three hours ready for him before he could be brought to table: and his man often said, when he has been getting up in a morning, he has sometimes begun to dress, and with one leg in his breeches sat down again on the bed, where he has remained for hours before he got his

cloaths on. From his love of peace, no doubt, arose that unusual kind of horror which he had for all disputes; a steady unbroken attention, free from those frequent recoilings inseparably incident to others, was his peculiar felicity; he knew it, and he knew the value of it. No wonder then that controversy was looked on as his bane. When some objections, hastily made to his discoveries concerning light and colours, induced him to lay aside the design he had of publishing his optic lectures, we find him reflecting on that dispute, into which he was unavoidably drawn thereby, in these terms: "I blamed my own imprudence for parting with so real a blessing as my quiet, to run after a shadow." It is true, this shadow (as Mr Fontenelle observes) did not escape him afterwards, nor did it cost him that quiet which he so much valued, but proved as much a real happiness to him as his quiet itself; yet this was a happiness of his own making: he took a resolution, from these disputes, not to publish any more about that theory till he had put it above the reach of controversy, by the exactest experiments and the strictest demonstrations; and accordingly it has never been called in question since. In the same temper, after he had sent the manuscript of his *Principia* to the Royal Society, with his consent to the printing of it by them, upon Mr Hook's injuriously insinuating that himself had demonstrated Kepler's problem before our author, he determined, rather than be involved again in a controversy, to suppress the third book, and was very hardly prevailed upon to alter that resolution. It is true, the public was thereby a gainer; that book, which is indeed no more than a corollary of some propositions in the first, being originally drawn up in the popular way, with a design to publish it in that form; whereas he was now convinced that it would be best not to let it go abroad without a strict demonstration.

After all, notwithstanding his anxious care to avoid every occasion of breaking his intense application to study, he was at a great distance from being steeped in philosophy: on the contrary, he could lay aside his thoughts, though engaged in the most intricate researches, when his other affairs required his attendance; and, as soon as he had leisure, resume the subject at the point where he had left off. This he seems to have done not so much by any extraordinary strength of memory, as by the force of his inventive faculty, to which every thing opened itself again with ease, if nothing intervened to ruffle him. The readiness of his invention made him not think of putting his memory much to the trial: but this was the offspring of a vigorous intenseness of thought, out of which he was but a common man. He spent, therefore, the prime of his age in those abstruse researches, when his situation in a college gave him leisure, and even while study was his proper profession. But as soon as he was removed to the mint, he applied himself chiefly to the business of that office; and so far quitted mathematics and philosophy, as not to engage in any pursuits of either kind afterwards.

The amiable quality of modesty is represented as standing foremost in the character of this great man's mind and manners. It was in reality greater than can be easily imagined, or will be readily believed: yet it always continued so without any alteration, though the whole world, says Fontenelle, conspired against it; and

^{Newton.} and let us add, though he was thereby robbed of his invention of fluxions. Nicholas Mercator publishing his *Logarithmotechnia* in 1668, where he gave the quadrature of the hyperbola by an infinite series, which was the first appearance in the learned world of a series of this sort drawn from the particular nature of the curve, and that in a manner very new and abstracted; Dr Barrow, then at Cambridge, where Mr Newton, at that time about 26 years of age, resided, recollected that he had met with the same thing in the writings of that young gentleman; and there not confined to the hyperbola only, but extended, by general forms, to all sorts of curves, even such as are mechanical; to their quadratures, their rectifications, and their centres of gravity; to the solids formed by their relations, and to the superficies of those solids; so that, when their determinations were possible, the series stopped at a certain point, or at least their sums were given by stated rules: and, if the absolute determinations were impossible, they could yet be infinitely approximated; which is the happiest and most refined method, says Mr Fontenelle, of supplying the defects of human knowledge that man's imagination could possibly invent. To be master of so fruitful and general a theory was a mine of gold to a geometrician; but it was a greater glory to have been the discoverer of so surprising and ingenious a system. So that Mr Newton, finding by Mercator's book, that he was in the way to it, and that others might follow in his tract, should naturally have been forward to open his treasures, and secure the property, which consisted in making the discovery; but he contented himself with his treasure which he had found, without regarding the glory. What an idea does it give us of his unparalleled modesty, when we see him declaring, that he thought Mercator had entirely discovered his secret, or that others would, before he was of a proper age for writing? His MS. upon infinite series was communicated to none but Mr John Collins and the Lord Brouncker; and even that had not been complied with, but for Dr Barrow, who would not suffer him to indulge his modesty so much as he desired.

It is further observed, concerning this part of his character, that he never talked either of himself or others, nor ever behaved in such a manner as to give the most malicious censurers the least occasion even to suspect him of vanity. He was candid and affable, and always put himself upon a level with his company. He never thought either his merit or his reputation sufficient to excuse him from any of the common offices of social life; no singularities, either natural or affected, distinguished him from other men. Though he was firmly attached to the church of England, he was averse to the persecution of the non-conformists. He judged of men by their manners; and the true schismatics, in his opinion, were the vicious and the wicked. Not that he confined his principles to natural religion, for he was thoroughly persuaded of the truth of revelation; and amidst the great variety of books which he had constantly before him, that which he studied with the greatest application was the Bible; and he understood the nature and force of moral certainty as well as he did that of a strict demonstration.

Sir Isaac did not neglect the opportunities of doing good, when the revenues of his patrimony, and a profitable employment, improved by a pru-

dent economy, put it in his power. We have two ^{Newtonian} remarkable instances of his bounty and generosity; ^{Philosophy.} one to Mr M'Laurin, professor of mathematics at Edinburgh, to whom he offered 20 l. per annum; and the other to his niece Barton, who had an annuity of 100 l. per annum settled upon her by him. When decency upon any occasion required expence and shew, he was magnificent without grudging it, and with a very good grace; at all other times, that pomp which seems great to low minds only, was utterly retrenched, and the expence reserved for better uses. He never married, and perhaps he never had leisure to think of it. Being immersed in profound studies during the prime of his age, and afterwards engaged in an employment of great importance, and even quite taken up with the company which his merit drew to him, he was not sensible of any vacancy in life, nor of the want of a companion at home. He left 32,000 l. at his death; but made no will, which Mr Fontenelle tells us was because he thought a legacy was no gift. As to his works, besides what were published in his life-time, there were found after his death, among his papers, several discourses upon the subjects of antiquity, history, divinity, chemistry, and mathematics, several of which were published at different times.

NEWTONIAN Philosophy, the doctrine of the universe, and particularly of the heavenly bodies, their laws, affections, &c. as delivered by Sir Isaac Newton.

The term *Newtonian Philosophy* is applied very differently; whence divers confused notions relating thereto. Some authors under this philosophy include all the corpuscular philosophy, considered as it now stands corrected and reformed by the discoveries and improvements made in several parts thereof by Sir Isaac Newton. In which sense it is that Gravesande calls his elements of physics, *Introductio ad Philosophiam Newtonianam*. And in this sense the Newtonian is the same with the new philosophy; and stands contradistinguished from the Cartesian, the Peripatetic, and the ancient Corpuscular. ^{Different opinions concerning this philosophy.}

Others, by *Newtonian Philosophy*, mean the method or order which Sir Isaac Newton observes in philosophizing; viz. the reasoning and drawing of conclusions directly from phenomena, exclusive of all previous hypotheses; the beginning from simple principles; deducing the first powers and laws of nature from a few select phenomena, and then applying those laws, &c. to account for other things. And in this sense the *Newtonian philosophy* is the same with the *experimental philosophy*, and stands opposed to the ancient *Corpuscular*.

Others, by *Newtonian philosophy*, mean that wherein physical bodies are considered mathematically, and where geometry and mechanics are applied to the solution of the appearances of nature. In which sense the Newtonian is the same with the *mechanical* and *mathematical philosophy*.

Others again, by *Newtonian philosophy*, understand that part of physical knowledge which Sir Isaac Newton has handled, improved, and demonstrated, in his *Principia*.

Others, lastly, by *Newtonian philosophy*, mean the new principles which Sir Isaac Newton has brought into philosophy; the new system founded thereon; and the new solutions of phenomena thence deduced; or

Newtonian or that which characterizes and distinguishes his philosophy from all others.—Which is the sense wherein we shall chiefly consider it.

As to the history of this philosophy, we have nothing to add to what has been given in the preceding article. It was first made public in the year 1687, by the author, then a fellow of Trinity-college, Cambridge; and in the year 1713, republished with considerable improvements.—Several authors have since attempted to make it plainer; by setting aside many of the more sublime mathematical researches, and substituting either more obvious reasonings or experiments in lieu thereof; particularly Whiston in his *Prælect. Phys. Mathemat.* Gravefande in *Element. & Instit.* and Dr Pemberton in his *View*.

The whole of the *Newtonian Philosophy*, as delivered by the author, is contained in his *Principia*, or *Mathematical Principles of Natural Philosophy*. He founds his system on the following definitions.

2
Definitions
on which
the philo-
sophy is
founded.

1. The quantity of matter is the measure of the same, arising from its density and bulk conjunctly.—Thus air of a double density, in a double space, is quadruple in quantity; in a triple space, sextuple in quantity, &c.

2. The quantity of motion is the measure of the same, arising from the velocity and quantity of matter conjunctly. This is evident, because the motion of the whole is the motion of all its parts; and therefore in a body double in quantity, with equal velocity, the motion is double, &c.

3
Vis inertia,
defined and
objected to.

3. The *vis inertia*, or innate force of matter, is a power of resisting, by which every body, as much as in it lies, endeavours to persevere in its present state, whether it be of rest, or moving uniformly forward in a right line.—This definition is proved to be just, only by the difficulty we find in moving any thing out of its place; and this difficulty is by some reckoned to proceed only from gravity. They contend, that in those cases where we can prevent the force of gravity from acting upon bodies, this power of resistance becomes insensible, and the greatest quantities of matter may be put in motion by the very least force. Thus there have been balances formed so exact, that when loaded with 200 weight in each scale, they would turn by the addition of a single drachm. In this case 400 lb. of matter was put in motion by a single drachm, i. e. by $\frac{1}{160}$ parts of its own quantity: and even this small weight, they say, is only necessary on account of the inaccuracy of the machine; so that we have no reason to suppose, that, if the friction could be entirely removed, it would take more force to move a tun weight than a grain of sand. This objection, however, is not taken notice of by Sir Isaac; and he bestows on the resisting power above-mentioned the name of *vis inertia*; a phrase which is perhaps not well chosen, and with which inferior writers have endeavoured to make their readers merry at the expence of Newton. A *force of inactivity*, it has been said, is a *forceless* force; and analogous to a *black white*, a *cold heat*, and a *tempestuous calm*.

*Young's
Examina-
tion of the
third and
fourth Defi-
nitions of the
first Book of
the *Princi-
pia*, &c.

But objections of more importance have been made to the whole of this doctrine than those which merely respect the term *vis inertia*. "An endeavour to remain at rest (we are told*) is unnecessary, whilst nothing attempts to disturb the rest. It is likewise im-

possible to be conceived, as it implies a contradiction. Newtonian
Philosophy.
A man, by opposing force to force, may endeavour not to be moved; but this opposition is an endeavour to move, not with a *design* to move, but by counter-acting another force to *prevent* being moved. An endeavour not to move therefore cannot exist in bodies, because it is absurd; and if we appeal to fact, we shall find every body in an actual and constant endeavour to move." It has been likewise observed, and we think justly, that "if bodies could *continue* to move by any innate force, they might also *begin* to move by that force. For the same cause which can move a body with a given velocity at one time, could do it, if present, at any other time; and therefore if the force by which bodies continue in motion were innate and essential to them, they would begin to move of themselves, which is not true." Newton indeed says that this innate force is the cause of motion under certain circumstances only, or when the body is acted upon by a force impressed *ab extra*. But if this impressed force do not continue as well as begin the motion, if it cease the instant that the impression is over, and the body continue to move by its *vis inertia*, why is the body ever stopped? "If in the beginning of the motion the body, by its innate force, overcomes a certain resistance of friction and air, in any following times, the force being undiminished, it will overcome the same resistance for ever. These resistances, therefore, could never change the state of a moving body, because they cannot change the quantity of its motive force. But this is contrary to universal experience." For these reasons we are inclined to think that bodies are wholly passive; that they endeavour nothing; and that they continue in motion not by any innate force or *vis inertia*, but by that force, whatever it be, which begins the motion, and which, whilst it remains with the moving body, is gradually diminished, and at last overcome by opposite forces, when the body of course ceases to move.

4. An impressed force is an action exerted upon a body, in order to change its state, either of rest, or of moving uniformly forward in a right line.—This force consists in the action only; and remains no longer in the body when the action is over. For a body maintains every new state it acquires by its *vis inertia* only.

It is here implied, and indeed fully expressed, that motion is not continued by the same power that produced it. Now there are two grounds on which the truth of this doctrine may be supposed to rest.

"First, On a direct proof that the impressed force does not remain in the body, either by showing the nature of the force to be transitory and incapable of more than its first action; or that it acts only on the surface, and that the body escapes from it; or that the force is somewhere else, and not remaining in the body. But none of these direct proofs are offered.

"Secondly, It may rest on an indirect proof, that there is in the nature of body a sufficient cause for the continuance of every new state acquired; and that therefore any adventitious force to continue motion, though necessary for its production, is superfluous and inadmissible. As this is the very ground on which the supposition stands, it ought to have been indubitably certain that the innate force of the body

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is sufficient to perpetuate the motion it has once acquired, before the other agent, by which the motion was communicated, had been dismissed from the office. But the innate force of body has been shown not to be that which continues its motion; and therefore the proof, that the impressed force does not remain in the body, fails. Nor indeed is it in this case desirable to support the proof, because we should then be left without any reason for the continuance of motion*." When we mention an impressed force, we mean such a force as is communicated either at the surface of the body or by being diffused through the mass.

* Young's
Examina-
tion, &c.

5. A centripetal force is that by which bodies are drawn, impelled, or any way tend towards a point, as to a centre.—The quantity of any centripetal force may be considered as of three kinds, absolute, accelerative, and motive.

6. The absolute quantity of a centrifugal force is the measure of the same, proportional to the efficacy of the cause that propagates it from the centre, through the spaces round about.

7. The accelerative quantity of a centripetal force is the measure of the same, proportional to the velocity which it generates in a given time.

8. The motive quantity of a centripetal force is a measure of the same, proportional to the motion which it generates in a given time.—This is always known by the quantity of a force equal and contrary to it, that is just sufficient to hinder the descent of the body.

SCHOLIA.

4
Of time.

I. Absolute, true, and mathematical time, of itself, and from its own nature, flows equably, without regard to any thing external, and, by another name, is called *duration*. Relative, apparent, and common time, is some sensible and external measure of duration, whether accurate or not, which is commonly used instead of true time; such as an hour, a day, a month, a year, &c.

5
Space.

II. Absolute space, in its own nature, without regard to any thing external, remains always similar and immovable. Relative space is some moveable dimension or measure of the absolute spaces; and which is vulgarly taken for immovable space. Such is the dimension of a subterraneous, an aerial, or celestial space, determined by its position to bodies, and which is vulgarly taken for immovable space; as the distance of a subterraneous, an aerial, or celestial space, determined by its position in respect of the earth. Absolute and relative space are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air which, relatively and in respect of the earth, remains always the same, will at one time be one part of the absolute space into which the earth passes; at another time it will be another part of the same; and so, absolutely understood, it will be perpetually mutable.

6
Place de-
lined.

III. Place is a part of space which a body takes up; and is, according to the space, either absolute or relative. Our author says it is *part* of space; not the situation, nor the external surface of the body. For the places of equal solids are always equal; but their superficies, by reason of their dissimilar figures,

N^o 241.

are often unequal. Positions properly have no quantity, nor are they so much the places themselves as the properties of places. The motion of the whole is the same thing with the sum of the motions of the parts; that is, the translation of the whole out of its place is the same thing with the sum of the translations of the parts out of their places: and therefore the place of the whole is the same thing with the sum of the places of the parts; and for that reason it is internal, and in the whole body.

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IV. Absolute motion is the translation of a body from one absolute place into another, and relative motion the translation from one relative place into another. Thus, in a ship under sail, the relative place of a body is that part of the ship which the body possesses, or that part of its cavity which the body fills, and which therefore moves together with the ship; and relative rest is the continuance of the body in the same part of the ship, or of its cavity. But real absolute rest is the continuance of the body in the same part of that immovable space in which the ship itself, its cavity, and all that it contains, is moved. Wherefore, if the earth is really at rest, the body which relatively rests in the ship will really and absolutely move with the same velocity which the ship has on the earth. But if the earth also moves, the true and absolute motion of the body will arise, partly from the true motion of the earth in immovable space; partly from the relative motion of the ship on the earth: and if the body moves also relatively in the ship, its true motion will arise partly from the true motion of the earth in immovable space, and partly from the relative motions as well of the ship on the earth as of the body in the ship; and from these relative motions will arise the relative motion of the body on the earth. As if that part of the earth where the ship is, was truly moved towards the east, with a velocity of 10010 parts; while the ship itself with a fresh gale is carried towards the west, with a velocity expressed by 10 of these parts; but a sailor walks in the ship towards the east with one part of the said velocity: then the sailor will be moved truly and absolutely in immovable space towards the east with a velocity of 1001 parts; and relatively on the earth towards the west, with a velocity of 9 of those parts.

Absolute time, in astronomy, is distinguished from relative, by the equation or correction of the vulgar time. For the natural days are truly unequal, though they are commonly considered as equal, and used for a measure of time: astronomers correct this inequality for their more accurate deducing of the celestial motions. It may be that there is no such thing as an equable motion whereby time may be accurately measured. All motions may be accelerated or retarded; but the true or equable progress of absolute time is liable to no change. The duration or perseverance of the existence of things remains the same, whether the motions are swift or slow, or none at all; and therefore ought to be distinguished from what are only sensible measures thereof and out of which we collect it by means of the astronomical equation. The necessity of which equation for determining the times of a phenomenon is evinced, as well from the experiments of the pendulum-clock as by eclipses of the satellites of Jupiter.

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8
Immutability of time
and space.

As the order of the parts of time is immutable, so also is the order of the parts of space. Suppose those parts to be moved out of their places, and they will be moved (if we may be allowed the expression) out of themselves. For times and spaces are, as it were, the places of themselves as of all other things. All things are placed in time as to order of succession; and in space as to order of situation. It is from their essence or nature that they are places; and that the primary places of things should be moveable, is absurd. These are therefore the absolute places; and translations out of those places are the only absolute motions.

But because the parts of space cannot be seen, or distinguished from one another by the senses, therefore in their stead we use sensible measures of them. For, from the positions and distances of things from any body, considered as immoveable, we define all places; and then with respect to such places, we estimate all motions, considering bodies as transferred from some of those places into others. And so, instead of absolute places and motions, we use relative ones; and that without any inconvenience in common affairs: but in philosophical disquisitions we ought to abstract from our senses, and consider things themselves distinct from what are only sensible measures of them. For it may be, that there is no body really at rest, to which the places and motions of others may be referred.

But we may distinguish rest and motion, absolute and relative, one from the other by their properties, causes, and effects. It is a property of rest, that bodies really at rest do rest in respect of each other. And therefore, as it is possible, that, in the remote regions of the fixed stars, or perhaps far beyond them, there may be some body absolutely at rest, tho' it be impossible to know from the position of bodies to one another in our regions, whether any of these do keep the same position to that remote body; it follows, that absolute rest cannot be determined from the position of bodies in our regions.

9
Of the motion of different bodies with respect to one another.

It is a property of motion, that the parts which retain given positions to their wholes do partake of the motion of their wholes. For all parts of revolving bodies endeavour to recede from the axis of motion; and the impetus of bodies moving forwards arises from the joint impetus of all the parts. Therefore if surrounding bodies are moved, those that are relatively at rest within them will partake of their motion. Upon which account the true and absolute motion of a body cannot be determined by the translation of it from those only which seem to rest; for the external bodies ought not only to appear at rest, but to be really at rest. For otherwise all included bodies, beside their translation from near the surrounding ones, partake likewise of their true motions; and though that translation was not made, they would not really be at rest, but only seem to be so. For the surrounding bodies stand in the like relation to the surrounded, as the exterior part of a whole does to the interior, or as the shell does to the kernel; but if the shell moves, the kernel will also move, as being part of the whole, without any removal from near the shell.

A property near akin to the preceding is, that if

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a place is moved, whatever is placed therein moves along with it; and therefore a body which is moved from a place in motion, partakes also of the motion of its place. Upon which account all motions from places in motion, are no other than parts of entire and absolute motions; and every entire motion is composed of the motion of the body out of its first place, and the motion of this place out of its place; and so on, until we come to some immoveable place, as in the above-mentioned example of the sailor. Wherefore entire and absolute motions can be no otherwise determined than by immoveable places. Now, no other places are immoveable but those that from infinity to infinity do all retain the same given positions one to another; and upon this account must ever remain unmoved, and do thereby constitute what we call *immoveable space*.

The causes by which true and relative motions are distinguished one from the other, are the forces impressed upon bodies to generate motion. True motion is neither generated nor altered, but by some force impressed upon the body moved: but relative motion may be generated or altered without any force impressed upon the body. For it is sufficient only to impress some force on other bodies with which the former is compared, that, by their giving way, that relation may be changed, in which the relative rest or motion of the other body did consist. Again, true motion suffers always some change from any force impressed upon the moving body; but relative motion does not necessarily undergo any changes by such force. For if the same forces are likewise impressed on those other bodies with which the comparison is made, that the relative position may be preserved; then that condition will be preserved, in which the relative motion consists. And therefore any relative motion may be changed when the true motion remains unaltered, and the relative may be preserved when the true motion suffers some change. Upon which account true motion does by no means consist in such relations.

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The effects which distinguish absolute from relative motion are, the forces of receding from the axis of circular motion. For there are no such forces in a circular motion purely relative: but, in a true and absolute circular motion, they are greater or less according to the quantity of the motion. If a vessel, hung by a long cord, is so often turned about that the cord is strongly twisted, then filled with water, and let go, it will be whirled about the contrary way; and while the cord is untwisting itself, the surface of the water will at first be plain, as before the vessel began to move; but the vessel, by gradually communicating its motion to the water, will make it begin sensibly to revolve, and recede by little and little from the middle, and ascend to the sides of the vessel, forming itself into a concave figure; and the swifter the motion becomes, the higher will the water rise, till at last, performing its revolutions in the same times with the vessel, it becomes relatively at rest in it. This ascent of the water shows its endeavour to recede from the axis of its motion; and the true and absolute circular motion of the water, which is here directly contrary to the relative, discovers itself, and may be measured by this endeavour. At first, when the relative motion in the water was greatest, it produced no en-

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Absolute and relative motion distinguished.

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deavour to recede from the axis; the water showed no tendency to the circumference, nor any ascent towards the sides of the vessel, but remained of a plain surface; and therefore its true circular motion had not yet begun. But afterwards, when the relative motion of the water had decreased, the ascent thereof towards the sides of the vessel proved its endeavour to recede from the axis; and this endeavour showed the real circular motion of the water perpetually increasing, till it had acquired its greatest quantity, when the water rested relatively in the vessel. And therefore this endeavour does not depend upon any translation of the water in respect of the ambient bodies; nor can true circular motion be defined by such translations. There is only one real circular motion of any one revolving body, corresponding to only one power of endeavouring to recede from its axis of motion, as its proper and adequate effect: but relative motions in one and the same body are innumerable, according to the various relations it bears to external bodies; and, like other relations, are altogether destitute of any real effect, otherwise than they may perhaps participate of that only true motion. And therefore, in the system which supposes that our heavens, revolving below the sphere of the fixed stars, carry the planets along with them, the several parts of those heavens and the planets, which are indeed relatively at rest in their heavens, do yet really move. For they change their position one to another, which never happens to bodies truly at rest; and being carried together with the heavens, participate of their motions, and, as parts of revolving wholes, endeavour to recede from the axis of their motion.

Wherefore relative quantities are not the quantities themselves whose names they bear, but those sensible measures of them, either accurate or inaccurate, which are commonly used instead of the measured quantities themselves. And then, if the meaning of words is to be determined by their use, by the names *time*, *space*, *place*, and *motion*, their measures are properly to be understood; and the expression will be unusual and purely mathematical, if the measured quantities themselves are meant.

It is indeed a matter of great difficulty to discover, and effectually to distinguish, the true motions of particular bodies from those that are only apparent: because the parts of that immoveable space in which those motions are performed, do by no means come under the observation of our senses. Yet we have some things to direct us in this intricate affair; and these arise partly from the apparent motions which are the difference of the true motions, partly from the forces which are the causes and effects of the true motions. For instance, if two globes, kept at a given distance one from the other by means of a cord that connects them, were revolved about their common centre of gravity; we might, from the tension of the cord, discover the endeavour of the globes to recede from the axis of motion, and from thence we might compute the quantity of their circular motions. And then, if any equal forces should be impressed at once on the alternate faces of the globes to augment or diminish their circular motions, from the increase or decrease of the tension of the cord we might infer the increment or decrement of their motions; and thence would be found on what faces those forces ought to

be impressed, that the motions of the globes might be most augmented; that is, we might discover their hindermost faces, or those which follow in the circular motion. But the faces which follow being known, and consequently the opposite ones that precede, we should likewise know the determination of their motions. And thus we might find both the quantity and determination of this circular motion, even in an immense vacuum, where there was nothing external or sensible, with which the globes might be compared. But now, if in that space some remote bodies were placed that kept always a given position one to another, as the fixed stars do in our regions; we could not indeed determine from the relative translation of the globes among those bodies, whether the motion did belong to the globes or to the bodies. But if we observed the cord, and found that its tension was that very tension which the motions of the globes required, we might conclude the motion to be in the globes, and the bodies to be at rest; and then, lastly, from the translation of the globes among the bodies, we should find the determination of their motions.

Having thus explained himself, Sir Isaac proposes to show how we are to collect the true motions from their causes, effects, and apparent differences; and *vice versa*, how, from the motions, either true or apparent, we may come to the knowledge of their causes and effects. In order to this, he lays down the following axioms or laws of motion.

I. EVERY BODY PERSEVERES IN ITS STATE OF REST, OR OF UNIFORM MOTION IN A RIGHT LINE, UNLESS IT IS COMPELLED TO CHANGE THAT STATE BY FORCES IMPRESSED UPON IT.—Sir Isaac's proof of this axiom is as follows: "Projectiles persevere in their motions, so far as they are not retarded by the resistance of the air, or impelled downwards by the force of gravity. A top, whose parts, by their cohesion, are perpetually drawn aside from rectilinear motions, does not cease its rotation otherwise than as it is retarded by the air. The greater bodies of the planets and comets, meeting with less resistance in more free spaces, preserve their motions, both progressive and circular, for a much longer time."—Notwithstanding this demonstration, however, the axiom hath been violently disputed. It hath been argued, that bodies continue in their state of motion because they are subjected to the continual impulse of an invisible and subtle fluid, which always pours in from behind, and of which all places are full. It hath been affirmed that motion is as natural to this fluid as rest is to all other matter. It is said, moreover, that it is impossible we can know in what manner a body would be influenced by moving forces if it was entirely destitute of gravity. According to what we can observe, the momentum of a body, or its tendency to move, depends very much on its gravity. A heavy cannon-ball will fly to a much greater distance than a light one, though both are actuated by an equal force. It is by no means clear, therefore, that a body totally destitute of gravity would have any proper momentum of its own; and if it had no momentum, it could not continue its motion for the smallest space of time after the moving power was withdrawn. Some have imagined that matter was capable of beginning motion of itself, and consequently that the axiom was false; because we see plainly that matter in some cases hath a tendency

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to the
law.

Newtonian Philosophy. to change from a state of motion to a state of rest, and from a state of rest to a state of motion. A paper appeared on this subject in the first volume of the Edinburgh Physical and Literary Essays; but the hypothesis never gained any ground.

2. THE ALTERATION OF MOTION IS EVER PROPORTIONAL TO THE MOTIVE FORCE IMPRESSED; AND IS MADE IN THE DIRECTION OF THE RIGHT LINE IN WHICH THAT FORCE IS IMPRESSED.—Thus, if any force generates a certain quantity of motion, a double force will generate a double quantity, whether that force be impressed all at once, or in successive moments. To this law no objection of consequence has ever been made. It is founded on this self-evident truth, that every effect must be proportional to its cause. Mr Young, who seems to be very ambitious of detecting the errors of Newton, finds fault indeed with the expressions in which the law is stated; but he owns, that if thus expressed, *The alteration of motion is proportional to the actions or resistances which produce it, and is in the direction in which the actions or resistances are made*, it would be unexceptionable.

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Objections
to the third
law.

3. TO EVERY ACTION THERE ALWAYS IS OPPOSED AN EQUAL RE-ACTION: OR THE MUTUAL ACTION OF TWO BODIES UPON EACH OTHER ARE ALWAYS EQUAL, AND DIRECTED TO CONTRARY PARTS.—This axiom is also disputed by many. In the above-mentioned paper in the Physical Essays, the author endeavours to make a distinction between re-action and resistance; and the same attempt has been made by Mr Young. "When an action generates no motion (says he), it is certain that its effects have been destroyed by a contrary and equal action. When an action generates two contrary and equal motions, it is also evident that mutual

Newtonian Philosophy. actions were exerted, equal and contrary to each other. All cases where one of these conditions are not found, are exceptions to the truth of the law. If a finger presses against a stone, the stone, if it does not yield to the pressure, presses as much upon the finger: but if the stone yields, it re-acts less than the finger acts; and if it should yield with all the momentum that the force of the pressure ought to generate, which it would do if it were not impeded by friction, or a medium, it would not re-act at all. So if the stone drawn by a horse, follows after the horse, it does not re-act so much as the horse acts; but only so much as the velocity of the stone is diminished by friction, and it is the re-action of friction only, not of the stone. The stone does not re-act because it does not act, it resists, but resistance is not action.

"In the loss of motion from a striking body, equal to the gain in the body struck, there is a plain solution without requiring any re-action. The motion *lost*, is identically that which is *found* in the other body; this supposition accounts for the whole phenomenon in the most simple manner. If it be not admitted, but the solution by re-action is insisted upon, it will be incumbent on the party to account for the whole effect of communication of motion; otherwise he will lie under the imputation of rejecting a solution which is simple, obvious, and perfect; for one complex, unnatural, and incomplete. However this may be determined, it will be allowed, that the circumstances mentioned, afford no ground for the inference, that action and re-action are equal, since appearances may be explained in another way" (A).

Others grant that Sir Isaac's axiom is very true in respect to terrestrial substances; but they affirm, that,

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(A) If there be a perfect reciprocity betwixt an impinging body and a body at rest sustaining its impulse, may we not at our pleasure consider either body as the agent, and the other as the resistant? Let a moving body, A, pass from north to south, an equal body B at rest, which receives the stroke of A, act upon A from south to north, and A resist in a contrary direction, both inelastic: let the motion reciprocally communicated be called six. Then B at rest communicates to A six degrees of motion towards the north, and receives six degrees towards the south. B having no other motion than the six degrees it communicated, will, by its equal and contrary loss and gain, remain in equilibrio. Let the original motion of A have been twelve, then A having received a contrary action equal to six, six degrees of its motion will be destroyed or in equilibrio; consequently, a motive force as six will remain to A towards the south, and B will be in equilibrio, or at rest. A will then endeavour to move with six degrees, or half its original motion, and B will remain at rest as before. A and B being equal masses, by the laws of communication three degrees of motion will be communicated to B, or A with its six degrees will act with three, and B will re-act also with three. B then will act on A from south to north equal to three, while it is acted upon or resisted by A from north to south, equal also to three, and B will remain at rest as before; A will also have its six degrees of motion reduced to one half by the contrary action of B, and only three degrees of motion will remain to A, with which it will yet endeavour to move; and finding B still at rest, the same process will be repeated till the whole motion of A is reduced to an infinitely small quantity, B all the while remaining at rest, and there will be no communication of motion from A to B, which is contrary to experience.

Let a body, A, whose mass is twelve, at rest, be impinged upon first by B, having a mass as twelve, and a velocity as four, making a momentum of 48; and secondly by C, whose mass is six, and velocity eight, making a momentum of 48 equal to B, the three bodies being inelastic. In the first case, A will become possessed of a momentum of 24, and 24 will remain to B; and, in the second case, A will become possessed of a momentum of 32, and 16 will remain to C, both bodies moving with equal velocities after the shock, in both cases, by the laws of percussio. It is required to know, if in both cases A resists equally, and if B and C act equally? If the actions and resistances are equal, how does A in one case destroy 24 parts of B's motion, and in the other case 32 parts of C's motion, by an equal resistance? And how does B communicate in one case 24 degrees of motion, and C 32, by equal actions? If the actions and resistances are unequal, it is asked how the same mass can resist differently to bodies impinging upon it with equal momenta, and how bodies

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in these, both action and re-action are the effects of gravity. Substances void of gravity would have no momentum; and without this they could not act; they would be moved by the least force, and therefore could not resist or re-act. If therefore there is any fluid which is the cause of gravity, though such fluid could act upon terrestrial substances, yet these could not re-act upon it; because they have no force of their own, but depend entirely upon it for their momentum. In this manner, say they, we may conceive that the planets circulate, and all the operations of nature are carried on by means of a subtle fluid; which being perfectly active, and the rest of matter altogether passive, there is neither resistance nor loss of motion. See MOTION.

From the preceding axiom Sir Isaac draws the following corollaries.

1. A body by two forces conjoined will describe the diagonal of a parallelogram in the same time that it would describe the sides by those forces apart.

2. Hence we may explain the composition of any one direct force out of any two oblique ones, viz. by making the two oblique forces the sides of a parallelogram, and the direct one the diagonal.

3. The quantity of motion, which is collected by taking the sum of the motions directed towards the same parts, and the difference of those that are directed to contrary parts, suffers no change from the action of bodies among themselves; because the motion which one body loses is communicated to another: and if we suppose friction and the resistance of the air to be absent, the motion of a number of bodies which mutually impelled one another would be perpetual, and its quantity always equal.

4. The common centre of gravity of two or more bodies does not alter its state of motion or rest by the actions of the bodies among themselves; and therefore the common centre of gravity of all bodies acting upon each other (excluding outward actions and impediments) is either at rest, or moves uniformly in a right line.

5. The motions of bodies included in a given space are the same among themselves, whether that space is at rest, or moves uniformly forward in a right line without any circular motion. The truth of this is evidently shown by the experiment of a ship; where all motions happen after the same manner, whether the ship is at rest, or proceeds uniformly forward in a straight line.

6. If bodies, any how moved among themselves, are urged in the direction of parallel lines by equal accelerative forces, they will all continue to move among themselves, after the same manner as if they had been urged by no such forces.

The whole of the mathematical part of the Newtonian philosophy depends on the following lemmas; of which the first is the principal.

LEM. I. Quantities, and the ratios of quantities,

which in any finite time converge continually to equality, and before that time approach nearer the one to the other than by any given difference, become ultimately equal. If you deny it; suppose them to be ultimately unequal, and let D be their ultimate difference. Therefore they cannot approach nearer to equality than by that given difference D; which is against the supposition.

Concerning the meaning of this lemma philosophers are not agreed; and unhappily it is the very fundamental position on which the whole of the system rests. Many objections have been raised to it by people who supposed themselves capable of understanding it. They say, that it is impossible we can come to an end of any infinite series, and therefore that the word *ultimate* can in this case have no meaning. In some cases the lemma is evidently false. Thus, suppose there are two quantities of matter A and B, the one containing half a pound, and the other a third part of one. Let both be continually divided by 2; and though their ratio, or the proportion of the one to the other, doth not vary, yet the difference between them perpetually becomes less, as well as the quantities themselves, until both the difference and quantities themselves become less than any assignable quantity; yet the difference will never totally vanish, nor the quantities become equal, as is evident from the two following series.

$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{128}$	$\frac{1}{256}$	$\frac{1}{512}$	$\frac{1}{1024}$	&c.
$\frac{1}{3}$	$\frac{1}{9}$	$\frac{1}{27}$	$\frac{1}{81}$	$\frac{1}{243}$	$\frac{1}{729}$	$\frac{1}{2187}$	$\frac{1}{6561}$	$\frac{1}{19683}$	$\frac{1}{59049}$	&c.
Diff.	$\frac{1}{6}$	$\frac{1}{12}$	$\frac{1}{24}$	$\frac{1}{48}$	$\frac{1}{96}$	$\frac{1}{192}$	$\frac{1}{384}$	$\frac{1}{768}$	$\frac{1}{1536}$	&c.

Thus we see, that though the difference is continually diminishing, and that in a very large proportion, there is no hope of its vanishing, or the quantities becoming equal. In like manner, let us take the proportions or ratios of quantities, and we shall be equally unsuccessful. Suppose two quantities of matter, one containing 8 and the other 10 pounds; these quantities already have to each other the ratio of 8 to 10, or of 4 to 5; but let us add 2 continually to each of them, and though the ratios continually come nearer to that of equality, it is in vain to hope for a perfect coincidence. Thus,

8	10	12	14	16	18	20	22	24	&c.
10	12	14	16	18	20	22	24	26	&c.
Ratio	$\frac{4}{5}$	$\frac{6}{7}$	$\frac{8}{9}$	$\frac{10}{11}$	$\frac{12}{13}$	$\frac{14}{15}$	$\frac{16}{17}$	$\frac{18}{19}$	&c.

For this and his other lemmas Sir Isaac makes the following apology. "These lemmas are premised, to avoid the tediousness of deducing perplexed demonstrations *ad absurdum*, according to the method of ancient geometers. For demonstrations are more contracted by the method of indivisibles: but because the hypothesis of indivisibles seems somewhat harsh, and therefore that method is reckoned less geometrical, I chose rather to reduce the demonstrations of the following propositions to the first and last sums and ratios of nascent and evanescent quantities, that is, to the limits of those sums and ratios; and so to premise, as short as I could, the demonstrations of those limits.

For

bodies possessed of equal momenta can exert different actions, it being admitted that bodies resist proportional to their masses, and that their power of overcoming resistance is proportional to their momenta?

It is incumbent on those who maintain the doctrine of universal re-action, to free it from these difficulties and apparent contradictions.

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Philosophy.14
Objections
to the first
lemma,

15

answered.

Newtonian Philosophy. For hereby the same thing is performed as by the method of indivisibles; and now those principles being demonstrated, we may use them with more safety. Therefore, if hereafter I should happen to consider quantities as made up of particles, or should use little curve lines for right ones; I would not be understood to mean indivisibles, but evanescent divisible quantities; not the sums and ratios of determinate parts, but always the limits of sums and ratios; and that the force of such demonstrations always depends on the method laid down in the foregoing lemmas.

“Perhaps it may be objected, that there is no ultimate proportion of evanescent quantities, because the proportion, before the quantities have vanished, is not the ultimate, and, when they are vanished, is none. But by the same argument it may be alleged, that a body arriving at a certain place, and there stopping, has no ultimate velocity; because the velocity before the body comes to the place is not its ultimate velocity; when it is arrived, it has none. But the answer is easy: for by the ultimate velocity is meant that with which the body is moved, neither before it arrives at its place and the motion ceases, nor after; but at the very instant it arrives; that is, that velocity with which the body arrives at its last place, and with which the motion ceases. And in like manner, by the ultimate ratio of evanescent quantities is to be understood the ratio of the quantities, not before they vanish, nor afterwards, but with which they vanish. In like manner, the first ratio of nascent quantities is that with which they begin to be. And the first or last sum is that with which they begin and cease to be (or to be augmented and diminished). There is a limit which the velocity at the end of the motion may attain, but not exceed; and this is the ultimate velocity. And there is the like limit in all quantities and proportions that begin and cease to be. And, since such limits are certain and definite, to determine the same is a problem strictly geometrical. But whatever is geometrical we may be allowed to make use of in determining and demonstrating any other thing that is likewise geometrical.

“It may be also objected, that if the ultimate ratios of evanescent quantities are given, their ultimate magnitudes will be also given; and so all quantities will consist of indivisibles, which is contrary to what Euclid has demonstrated concerning incommensurables, in the 10th book of his elements. But this objection is founded on a false supposition. For those ultimate ratios with which quantities vanish are not truly the ratios of ultimate quantities, but limits towards which the ratios of quantities decreasing continually approach.”

LEM. II. If in any figure $AacE$ (Pl. CCCXLV. n° 1.) terminated by the right line Aa , AE , and the curve acE , there be inscribed any number of parallelograms Ab , Bc , Cd , &c. comprehended under equal bases AB , BC , CD , &c. and the sides Bb , Cc , Dd , &c. parallel to one side Aa of the figure; and the parallelograms $aKbl$, $bLcm$, $cMdn$, &c. are completed. Then if the breadth of these parallelograms be supposed to be diminished, and their number augmented in infinitum; the ultimate ratios which the inscribed figure $AKbLcMdD$, the circumscribed figure $AalbmcndoE$, and curvilinear figure Aa

$bcdE$, will have to one another, are ratios of equality. **Newtonian Philosophy.** —For the difference of the inscribed and circumscribed figures is the sum of the parallelograms Kl , Lm , Mn , Do ; that is, (from the equality of all their bases), the rectangle under one of their bases Kb , and the sum of their altitudes Aa , that is, the rectangle $ABla$. But this rectangle, because its breadth AB is supposed diminished in infinitum, becomes less than any given space. And therefore, by lem. I. the figures inscribed and circumscribed become ultimately equal the one to the other; and much more will the intermediate curvilinear figure be ultimately equal to either.

LEM. III. The same ultimate ratios are also ratios of equality, when the breadths AB , BC , CD , &c. of the parallelograms are unequal, and are all diminished in infinitum.—The demonstration of this differs but little from that of the former.

In his succeeding lemmas, Sir Isaac goes on to prove, in a manner similar to the above, that the ultimate ratios of the sine, chord, and tangent of arcs infinitely diminished, are ratios of equality, and therefore that in all our reasonings about these we may safely use the one for the other:—that the ultimate form of evanescent triangles made by the arc, chord, and tangent, is that of similitude, and their ultimate ratio is that of equality; and hence, in reasonings about ultimate ratios, we may safely use these triangles for each other, whether made with the sine, the arc, or the tangent.—He then shows some properties of the ordinates of curvilinear figures; and proves that the spaces which a body describes by any finite force urging it, whether that force is determined and immutable, or is continually augmented or continually diminished, are, in the very beginning of the motion, one to the other in the duplicate ratio of the powers. And, lastly, having added some demonstrations concerning the evanescence of angles of contact, he proceeds to lay down the mathematical part of his system, and which depends on the following theorems.

THEOR. I. The areas which revolving bodies describe by radii drawn to an immoveable centre of force, lie in the same immoveable planes, and are proportional to the times in which they are described.—For, suppose the time to be divided into equal parts, and in the first part of that time, let the body by its innate force describe the right line AB (n° 2.); in the second part of that time, the same would, by law 1. if not hindered, proceed directly to c along the line $Bc = AB$; so that by the radii AS , BS , cS , drawn to the centre, the equal areas ASB , $BS c$, would be described. But, when the body is arrived at B , suppose the centripetal force acts at once with a great impulse, and, turning aside the body from the right line Bc , compels it afterwards to continue its motion along the right line BC . Draw cC parallel to BS , meeting BC in C ; and at the end of the second part of the time, the body, by cor. 1. of the laws, will be found in C , in the same plane with the triangle ASB . Join SC ; and because SB and cC are parallel, the triangle SBC will be equal to the triangle SBC , and therefore also to the triangle SAB . By the like argument, if the centripetal force acts successively in C , D , E , &c. and makes the body in each single particle of time to describe the right lines CD , DE , EF ,

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EF, &c. they will all lie in the same plane; and the triangle SCD will be equal to the triangle SBC, and SDE to SCD, and SEF to SDE. And therefore, in equal times, equal areas are described in one immoveable plane; and, by composition, any sums SADS, SAFS, of those areas are, one to the other, as the times in which they are described. Now, let the number of those triangles be augmented, and their size diminished *in infinitum*; and then, by the preceding lemmas, their ultimate perimeter ADF will be a curve line: and therefore the centripetal force by which the body is perpetually drawn back from the tangent of this curve will act continually; and any described areas SADS, SAFS, which are always proportional to the times of description, will, in this case also, be proportional to those times Q. E. D.

COR. 1. The velocity of a body attracted towards an immoveable centre, in spaces void of resistance, is reciprocally as the perpendicular let fall from that centre on the right line which touches the orbit. For the velocities in these places A, B, C, D, E, are as the bases AB, BC, DE, EF, of equal triangles; and these bases are reciprocally as the perpendiculars let fall upon them.

COR. 2. If the chords AB, BC, of two arcs successively described in equal times by the same body, in spaces void of resistance, are completed into a parallelogram ABCV, and the diagonal BV of this parallelogram, in the position which it ultimately acquires when those arcs are diminished *in infinitum*, is produced both ways, it will pass through the centre of force.

COR. 3. If the chords AB, BC, and DE, EF, of arcs described in equal times, in spaces void of resistance, are completed into the parallelograms ABCV, DEFZ, the forces in B and E are one to the other in the ultimate ratio of the diagonals BV, EZ, when those arcs are diminished *in infinitum*. For the motions BC and EF of the body (by cor. 1. of the laws), are compounded of the motions Bc, BV and Ef, EZ; but BV and EZ, which are equal to Cc and Ff, in the demonstration of this proposition, were generated by the impulses of the centripetal force in B and E, and are therefore proportional to those impulses.

COR. 4. The forces by which bodies, in spaces void of resistance, are drawn back from rectilinear motions, and turned into curvilinear orbits, are one to another as the versed sines of arcs described in equal times; which versed sines tend to the centre of force, and bisect the chords when these arcs are diminished to infinity. For such versed sines are the halves of the diagonals mentioned in cor. 3.

COR. 5. And therefore those forces are to the force of gravity, as the said versed sines to the versed sines perpendicular to the horizon of those parabolic arcs which projectiles describe in the same time.

COR. 6. And the same things do all hold good (by cor. 5. of the laws) when the planes in which the bodies are moved, together with the centres of force, which are placed in those planes, are not at rest, but move uniformly forward in right lines.

THEOR. II. Every body that moves in any curve line described in a plane, and, by a radius drawn to a point either immoveable or moving forward with an

uniform rectilinear motion, describes about that point areas proportional to the times, is urged by a centripetal force directed to that point. Newtonian
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CASE I. For every body that moves in a curve line is (by law 1.) turned aside from its rectilinear course by the action of some force that impels it; and that force by which the body is turned off from its rectilinear course, and made to describe in equal times the least equal triangles SAB, SBC, SCD, &c. about the immoveable point S, (by Prop. 40. E. 1. and law 2.) acts in the place B according to the direction of a line parallel to C; that is, in the direction of the line BS; and in the place C according to the direction of a line parallel to dD, that is, in the direction of the line CS, &c.; and therefore acts always in the direction of lines tending to the immoveable point S. Q. E. D.

CASE II. And (by cor. 5. of the laws) it is indifferent whether the superficies in which a body describes a curvilinear figure be quiescent, or moves together with the body, the figure described, and its point S, uniformly forward in right lines.

COR. 1. In non-resisting spaces or mediums, if the areas are not proportional to the times, the forces are not directed to the point in which the radii meet; but deviate therefrom *in consequentia*, or towards the parts to which the motion is directed, if the description of the areas is accelerated; but *in antecedentia* if retarded.

COR. 2. And even in resisting mediums, if the description of the areas is accelerated, the directions of the forces deviate from the point in which the radii meet, towards the parts to which the motion tends.

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A body may be urged by a centripetal force compounded of several forces. In which case the meaning of the proposition is, that the force which results out of all tends to the point S. But if any force acts perpetually in the direction of lines perpendicular to the described surface, this force will make the body to deviate from the plane of its motion, but will neither augment nor diminish the quantity of the described surface; and is therefore not to be neglected in the composition of forces.

THEOR. III. Every body that, by a radius drawn to the centre of another body, howsoever moved, describes areas about that centre proportional to the times, is urged by a force compounded of the centripetal forces tending to that other body, and of all the accelerative force by which that other body is impelled.—The demonstration of this is a natural consequence of the theorem immediately preceding.

Hence, if the one body L, by a radius drawn to the other body T, describes areas proportional to the times, and from the whole force by which the first body L is urged, (whether that force is simple, or, according to cor. 2. of the laws, compounded of several forces), we subduct that whole accelerative force by which the other body is urged; the whole remaining force by which the first body is urged will tend to the other body T, as its centre.

And *vice versa*, if the remaining force tends nearly to the other body T, those areas will be nearly proportional to the times.

If

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If the body L, by a radius drawn to the other body T, describes areas, which, compared with the times, are very unequal, and that other body T be either at rest, or moves uniformly forward in a right line, the action of the centripetal force tending to that other body T is either none at all, or it is mixed and combined with very powerful actions of other forces: and the whole force compounded of them all, if they are many, is directed to another (immoveable or moveable) centre. The same thing obtains when the other body is actuated by any other motion whatever; provided that centripetal force is taken which remains after subducting that whole force acting upon that other body T.

S C H O L I U M.

Because the equable description of areas indicates that a centre is respected by that force with which the body is most affected, and by which it is drawn back from its rectilinear motion, and retained in its orbit, we may always be allowed to use the equable description of areas as an indication of a centre about which all circular motion is performed in free spaces.

THEOR. IV. The centripetal forces of bodies which by equable motions describe different circles, tend to the centres of the same circles; and are one to the other as the squares of the arcs described in equal times applied to the radii of circles.—For these forces tend to the centres of the circles, (by theor. 2. and cor. 2. theor. 1.) and are to one another as the versed sines of the least arcs described in equal times, (by cor. 4. theor. 1.) that is, as the squares of the same arcs applied to the diameters of the circles, by one of the lemmas; and therefore, since those arcs are as arcs described in any equal times, and the diameters are as the radii, the forces will be as the squares of any arcs described in the same time, applied to the radii of the circles. Q. E. D.

COR. 1. Therefore, since those arcs are as the velocities of the bodies, the centripetal forces are in a ratio compounded of the duplicate ratio of the velocities directly, and of the simple ratio of the radii inversely.

COR. 2. And since the periodic times are in a ratio compounded of the ratio of the radii directly, and the ratio of the velocities inversely; the centripetal forces are in a ratio compounded of the ratio of the radii directly, and the duplicate ratio of the periodic times inversely.

COR. 3. Whence, if the periodic times are equal, and the velocities therefore as the radii, the centripetal forces will be also as the radii; and the contrary.

COR. 4. If the periodic times and the velocities are both in the subduplicate ratio of the radii, the centripetal forces will be equal among themselves; and the contrary.

COR. 5. If the periodic times are as the radii, and therefore the velocities equal, the centripetal forces will be reciprocally as the radii; and the contrary.

COR. 6. If the periodic times are in the sesquialterate ratio of the radii, and therefore the velocities reciprocally in the subduplicate ratio of the radii, the

centripetal forces will be in the duplicate ratio of the radii inversely; and the contrary.

COR. 7. And universally, if the periodic time is as any power R^n of the radius R , and therefore the velocity reciprocally as the power R^{n-1} of the radius, the centripetal force will be reciprocally as the power R^{2n-2} of the radius; and the contrary.

COR. 8. The same things all hold concerning the times, the velocities, and forces, by which bodies describe the similar parts of any similar figures, that have their centres in a similar position within those figures, as appears by applying the demonstrations of the preceding cases to those. And the application is easy, by only substituting the equable description of areas in the place of equable motion, and using the distances of the bodies from the centres instead of the radii.

COR. 9. From the same demonstration it likewise follows, that the arc which a body uniformly revolving in a circle by means of a given centripetal force describes in any time, is a mean proportional between the diameter of the circle, and the space which the same body, falling by the same given force, would descend through in the same given time.

“By means of the preceding proposition and its corollaries (says Sir Isaac), we may discover the proportion of a centripetal force to any other known force, such as that of gravity. For if a body by means of its gravity revolves in a circle concentric to the earth, this gravity is the centripetal force of that body. But from the descent of heavy bodies, the time of one entire revolution, as well as the arc described in any given time, is given (by cor. 9. of this theorem). And by such propositions Mr Huygens, in his excellent book *De Horologio Oscillatorio*, has compared the force of gravity with the centrifugal forces of revolving bodies.

The preceding proposition may also be demonstrated in the following manner. In any circle suppose a polygon to be inscribed of any number of sides. And if a body, moved with a given velocity along the sides of the polygon, is reflected from the circle at the several angular points; the force with which, at every reflection it strikes the circle, will be as its velocity; and therefore the sum of the forces, in a given time, will be as that velocity and the number of reflections conjunctly; that is, (if the species of the polygon be given), as the length described in that given time, and increased or diminished in the ratio of the same length to the radius of the circle; that is, as the square of that length applied to the radius; and therefore, if the polygon, by having its sides diminished in infinitum, coincides with the circle, as the square of the arc described in a given time applied to the radius. This is the centrifugal force, with which the body impels the circle; and to which the contrary force, wherewith the circle continually repels the body towards the centre, is equal.

On these principles hangs the whole of Sir Isaac Newton's mathematical philosophy. He now shows how to find the centre to which the forces impelling any body are directed, having the velocity of the body given: and finds the centrifugal force to be always as the versed sine of the nascent arc directly, and as the square

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square of the time inversely; or directly as the square of the velocity, and inversely as the chord of the nascent arc. From these premisses he deduces the method of finding the centripetal force directed to any given point when the body revolves in a circle; and this whether the central point is near or at an immense distance; so that all the lines drawn from it may be taken for parallels. The same thing he shows with regard to bodies revolving in spirals, ellipses, hyperbolas, or parabolas — Having the figures of the orbits given, he shows also how to find the velocities and moving powers; and, in short, solves all the most difficult problems relating to the celestial bodies with an astonishing degree of mathematical skill. These problems and demonstrations are all contained in the first book of the *Principia*: but to give an account of them here would far exceed our limits; neither would many of them be intelligible, excepting to first-rate mathematicians.

16
Rules for
philosophi-
cal reason-
ing.

In the second book, Sir Isaac treats of the properties of fluids, and their powers of resistance; and here he lays down such principles as entirely overthrow the doctrine of Des Cartes's vortices, which was the fashionable system in his time. In the third book, he begins particularly to treat of the natural phenomena, and apply them to the mathematical principles formerly demonstrated; and, as a necessary preliminary to this part, he lays down the following rules for reasoning in natural philosophy.

1. We are to admit no more causes of natural things than such as are both true and sufficient to explain their natural appearances.
2. Therefore to the same natural effects we must always assign, as far as possible, the same causes.
3. The qualities of bodies which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.
4. In experimental philosophy, we are to look upon propositions collected by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions.

The phenomena first considered, are, 1. That the satellites of Jupiter by radii drawn to the centre of their primary, describe areas proportional to the times of their description; and that their periodic times, the fixed stars being at rest, are in the sesquuplicate ratio of their distances from its centre. 2. The same thing is likewise observed of the phenomena of Saturn. 3. The five primary planets, Mercury, Venus, Mars, Jupiter, and Saturn, with their several orbits, encompass the sun. 4. The fixed stars being supposed at rest, the periodic times of the five primary planets, and of the earth, about the sun, are in the sesquuplicate proportion of their mean distances from the sun. 5. The primary planets, by radii drawn to the earth, describe areas no ways proportionable to the times: but the areas which they describe by radii drawn to the sun are proportional to the times of description. 6. The moon, by a radius drawn to the centre of the earth, describes an area proportional to the time of description. All

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these phenomena are undeniable from astronomical observations, and are explained at large under the article ASTRONOMY. The mathematical demonstrations are next applied by Sir Isaac Newton in the following propositions.

PROP. I. The forces by which the satellites of Jupiter are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to the centre of that planet; and are reciprocally as the squares of the distances of those satellites from that centre. The former part of this proposition appears from theor. 2. or 3. and the latter from cor. 6. of theor. 5.; and the same thing we are to understand of the satellites of Saturn.

PROP. II. The forces by which the primary planets are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to the sun; and are reciprocally as the squares of the distances from the sun's centre. The former part of this proposition is manifest from phenomenon 5. just mentioned, and from theor. 2.; the latter from phenomenon 4. and cor. 6. of theor. 4. But this part of the proposition is with great accuracy deducible from the quiescence of the aphelion points. For a very small aberration from the reciprocal duplicate proportion would produce a motion of the apsides, sensible in every single revolution, and in many of them enormously great.

PROP. III. The force by which the moon is retained in its orbit, tends towards the earth; and is reciprocally as the square of the distance of its place from the centre of the earth. The former part of this proposition is evident from phenom. 5. and theor. 2.; the latter from phenom. 6. and theor. 2. or 3. It is also evident from the very slow motion of the moon's apogee; which, in every single revolution, amounting but to 3° 3' in *consequentia*, may be neglected: and this more fully appears from the next proposition.

PROP. IV. The moon gravitates towards the earth, and by the force of gravity is continually drawn off from a rectilinear motion, and retained in its orbit. — The mean distance of the moon from the earth in the syzgies in semidiameters of the latter, is about 60½. Let us assume the mean distance of 60 semidiameters in the syzgies; and suppose one revolution of the moon in respect of the fixed stars to be completed in 27^d. 7^h. 43', as astronomers have determined; and the circumference of the earth to amount to 123,249,600 Paris feet. Now, if we imagine the moon, deprived of all motion, to be let go, so as to descend towards the earth with the impulse of all that force by which it is retained in its orbit, it will, in the space of one minute of time, describe in its fall 15¼ Paris feet. For the versed sine of that arc which the moon, in the space of one minute of time, describes by its mean motion at the distance of 60 semidiameters of the earth, is nearly 15½ Paris feet; or more accurately, 15 feet 1 inch and one line ⅔. Wherefore since that force, in approaching to the earth, increases in the reciprocal duplicate proportion of the distance; and, upon that account, at the surface of the earth is 60×60 times greater than at the moon; a body in our regions, falling with that force, ought, in the space of one minute of time, to describe 60×60×15½ Paris feet; and in the space of one second of time to describe 15½ of those feet; or, more accurately, 15 feet 1 inch,

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1 inch, 1 line $\frac{4}{5}$. And with this very force we actually find that bodies here on earth do really descend.— For a pendulum oscillating seconds in the latitude of Paris, will be three Paris feet and $8\frac{1}{2}$ lines in length, as Mr Huygens has observed. And the space which a heavy body describes by falling one second of time, is to half the length of the pendulum in the duplicate ratio of the circumference of the circle to its diameter; and is therefore 15 Paris feet, 1 inch, 1 line $\frac{7}{8}$. And therefore the force by which the moon is retained in its orbit, becomes, at the very surface of the earth, equal to the force of gravity which we observe in heavy bodies there. And therefore (by rule 1. and 2.) the force by which the moon is retained in its orbit is that very same force which we commonly call *gravity*. For were gravity another force different from that, then bodies descending to the earth with the joint impulse of both forces, would fall with a double velocity, and, in the space of one second of time, would describe $30\frac{1}{2}$ Paris feet; altogether against experience.

The demonstration of this proposition may be more diffusely explained after the following manner. Suppose several moons to revolve about the earth, as in the system of Jupiter or Saturn, the periodic times of those moons would (by the argument of induction) observe the same law which Kepler found to obtain among the planets; and therefore their centripetal forces would be reciprocally as the squares of the distances from the centre of the earth, by Prop. I. Now, if the lowest of these were very small, and were so near the earth as almost to touch the tops of the highest mountains, the centripetal force thereof, retaining it in its orbit, would be very nearly equal to the weights of any terrestrial bodies that should be found upon the tops of these mountains; as may be known from the foregoing calculation. Therefore, if the same little moon should be deserted by its centrifugal force that carries it through its orbit, it would descend to the earth; and that with the same velocity as heavy bodies do actually descend with upon the tops of those very mountains, because of the equality of forces that oblige them both to descend. And if the force by which that lowest moon would descend were different from that of gravity, and if that moon were to gravitate towards the earth, as we find terrestrial bodies do on the tops of mountains, it would then descend with twice the velocity, as being impelled by both these forces conspiring together. Therefore, since both these forces, that is, the gravity of heavy bodies, and the centripetal forces of the moons, respect the centre of the earth, and are similar and equal between themselves, they will (by rule 1. and 2.) have the same cause. And therefore the force which retains the moon in its orbit, is that very force which we commonly call *gravity*; because otherwise, this little moon at the top of a mountain must either be without gravity, or fall twice as swiftly as heavy bodies use to do.

Having thus demonstrated that the moon is retained in its orbit by its gravitation towards the earth, it is easy to apply the same demonstration to the motions of the other secondary planets, and of the primary planets round the sun, and thus to show that gravitation prevails throughout the whole creation; after which, Sir Isaac proceeds to show from the same principles,

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that the heavenly bodies gravitate towards each other, and contain different quantities of matter, or have different densities in proportion to their bulks. Newtonian
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PROP. V. All bodies gravitate towards every planet; and the weights of bodies towards the same planet, at equal distances from its centre, are proportional to the quantities of matter they contain.

It has been confirmed by many experiments, that all sorts of heavy bodies (allowance being made for the inequality of retardation by some small resistance of the air) descend to the earth from equal heights in equal times; and that equality of times we may distinguish to a great accuracy by the help of pendulums. Sir Isaac Newton tried the thing in gold, silver, lead, glass, sand, common salt, wood, water, and wheat. He provided two wooden boxes, round and equal, filled the one with wood, and suspended an equal weight of gold in the centre of oscillation of the other. The boxes hanging by equal threads of 11 feet, made a couple of pendulums, perfectly equal in weight and figure, and equally receiving the resistance of the air. And placing the one by the other, he observed them to play together forwards and backwards, for a long time, with equal vibrations. And therefore the quantity of matter in the gold was to the quantity of matter in the wood, as the action of the motive force (or *vis motrix*) upon all the gold, to the action of the same upon all the wood; that is, as the weight of the one to the weight of the other. And the like happened in the other bodies. By these experiments, in bodies of the same weight, he could manifestly have discovered a difference of matter less than the thousandth part of the whole, had any such been. But, without all doubt, the nature of gravity towards the planets, is the same as towards the earth. For, should we imagine our terrestrial bodies removed to the orb of the moon, and there, together with the moon, deprived of all motion, to be let go, so as to fall together towards the earth; it is certain, from what we have demonstrated before, that, in equal times, they would describe equal spaces with the moon, and of consequence are to the moon, in quantity of matter, as their weights to its weight. Moreover, since the satellites of Jupiter perform their revolutions in times which observe the sesquiplicate proportion of their distances from Jupiter's centre, their accelerative gravities towards Jupiter will be reciprocally as the squares of their distances from Jupiter's centre; that is, equal at equal distances. And therefore, these satellites, if supposed to fall towards Jupiter from equal heights, would describe equal spaces in equal times, in like manner as heavy bodies do on our earth. And by the same argument, if the circumsolar planets were supposed to be let fall at equal distances from the sun, they would, in their descent towards the sun, describe equal spaces in equal times. But forces, which equally accelerate unequal bodies, must be as those bodies; that is to say, the weights of the planets towards the sun must be as their quantities of matter. Further, that the weights of Jupiter and of his satellites towards the sun are proportional to the several quantities of their matter, appears from the exceeding regular motions of the satellites. For if some of those bodies were more strongly attracted to the sun in proportion to their quantity of matter than others, the motions of the satellites would be disturbed by that inequality of attraction. If, at equal

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equal distances from the sun, any satellite, in proportion to the quantity of its matter, did gravitate towards the sun, with a force greater than Jupiter in proportion to his, according to any given proportion, suppose of d to e ; then the distance between the centres of the sun and of the satellite's orbit would be always greater than the distance between the centres of the sun and of Jupiter nearly in the subduplicate of that proportion. And if the satellite gravitated towards the sun with a force less in the proportion of e to d , the distance of the centre of the satellite's orb from the sun would be less than the distance of the centre of Jupiter's from the sun in the subduplicate of the same proportion. Therefore, if, at equal distances from the sun, the accelerative gravity of any satellite towards the sun were greater or less than the accelerating gravity of Jupiter towards the sun but by $\frac{1}{1000}$ part of the whole gravity; the distance of the centre of the satellite's orbit from the sun would be greater or less than the distance of Jupiter from the sun by $\frac{1}{1000}$ part of the whole distance; that is, by a fifth part of the distance of the utmost satellite from the centre of Jupiter; an eccentricity of the orbit which would be very sensible. But the orbits of the satellites are concentric to Jupiter; therefore the accelerative gravities of Jupiter, and of all its satellites, towards the sun, are equal among themselves. And by the same argument, the weight of Saturn and of his satellites towards the sun, at equal distances from the sun, are as their several quantities of matter; and the weights of the moon and of the earth towards the sun, are either none, or accurately proportional to the masses of matter which they contain.

But further, the weights of all the parts of every planet towards any other planet are one to another as the matter in the several parts. For if some parts gravitated more, others less, than in proportion to the quantity of their matter; then the whole planet, according to the sort of parts with which it most abounds, would gravitate more or less than in proportion to the quantity of matter in the whole. Nor is it of any moment whether these parts are external or internal. For if, as an instance, we should imagine the terrestrial bodies with us to be raised up to the orb of the moon, to be there compared with its body; if the weights of such bodies were to the weights of the external parts of the moon as the quantities of matter in the one and in the other respectively, but to the weights of the internal parts in a greater or less proportion; then likewise the weights of those bodies would be to the weight of the whole moon in a greater or less proportion; against what we have shewed above.

COR. 1. Hence the weights of bodies do not depend upon their forms and textures. For if the weights could be altered with the forms, they would be greater or less, according to the variety of forms in equal matter; altogether against experience.

COR. 2. Universally, all bodies about the earth gravitate towards the earth; and the weights of all, at equal distances from the earth's centre, are as the quantities of matter which they severally contain. This is the quality of all bodies within the reach of our experiments; and therefore (by rule 3.) to be affirmed of all bodies whatsoever. If ether, or any other body, were either altogether void of gravity, or were to gravitate less in proportion to its quantity of matter;

then, because (according to Aristotle, Des Cartes, and others) there is no difference betwixt that and other bodies; but in mere form of matter, by a successive change from form to form, it might be changed at last into a body of the same condition with those which gravitate most in proportion to their quantity of matter; and, on the other hand, the heaviest bodies, acquiring the first form of that body, might by degrees quite lose their gravity. And therefore the weights would depend upon the forms of bodies, and with those forms might be changed, contrary to what was proved in the preceding corollary.

COR. 3. All spaces are not equally full. For if all spaces were equally full, then the specific gravity of the fluid which fills the region of the air, on account of the extreme density of the matter, would fall nothing short of the specific gravity of quick-silver or gold, or any other the most dense body; and therefore, neither gold, nor any other body, could descend in air. For bodies do not descend in fluids, unless they are specifically heavier than the fluids. And if the quantity of matter in a given space can by any rarefaction be diminished, what should hinder a diminution to infinity?

COR. 4. If all the solid particles of all bodies are of the same density, nor can be rarefied without pores, a void space or vacuum must be granted. [By bodies of the same density, our author means those whose *vires inertiae* are in the proportion of their bulks.]

PROP. VI. That there is a power of gravity tending to all bodies, proportional to the several quantities of matter which they contain.

That all the planets mutually gravitate one towards another, we have proved before; as well as that the force of gravity towards every one of them, considered apart, is reciprocally as the square of the distance of places from the centre of the planet. And thence it follows, that the gravity tending towards all the planets is proportional to the matter which they contain.

Moreover, since all the parts of any planet A gravitate towards any other planet B , and the gravity of every part is to the gravity of the whole as the matter of the part to the matter of the whole; and (by law 3.) to every action corresponds an equal re-action: therefore the planet B will, on the other hand, gravitate towards all the parts of the planet A ; and its gravity towards any one part will be to the gravity towards the whole, as the matter of the part to the matter of the whole. Q. E. D.

COR. 1. Therefore the force of gravity towards any whole planet, arises from, and is compounded of, the forces of gravity towards all its parts. Magnetic and electric attractions afford us examples of this. For all attraction towards the whole arises from the attractions towards the several parts. The thing may be easily understood in gravity, if we consider a greater planet as formed of a number of lesser planets, meeting together in one globe. For hence it would appear that the force of the whole must arise from the forces of the component parts. If it be objected, that, according to this law, all bodies with us must mutually gravitate one towards another, whereas no such gravitation any where appears; it is answered, that, since the gravitation towards these bodies is to the gravitation towards the whole earth, as these bodies are to the whole earth, the gravitation towards them must be far less than to fall

Newtonian fall under the observation of our senses. [The experiments with regard to the attraction of mountains, however, have now further elucidated this point.]

COR. 2. The force of gravity towards the several equal particles of any body, is reciprocally as the square of the distance of places from the particles.

PROP. VII. In two spheres mutually gravitating each towards the other, if the matter, in places on all sides round about and equidistant from the centres, is similar; the weight of either sphere towards the other will be reciprocally as the square of the distance between their centres.

For the demonstration of this, see the *Principia*, book i. prop. 75. and 76.

COR. I. Hence we may find and compare together the weights of bodies towards different planets. For the weights of bodies revolving in circles about planets are as the diameters of the circles directly, and the squares of their periodic times reciprocally; and their weights at the surfaces of the planets, or at any other distances from their centres, are (by this prop.) greater or less, in the reciprocal duplicate proportion of the distances. Thus from the periodic times of Venus, revolving about the sun, in 224d. 16 $\frac{3}{4}$ h; of the utmost circumjovial satellite revolving about Jupiter, in 16d. 16 $\frac{3}{4}$ h; of the Huygenian satellite about Saturn in 15d. 22 $\frac{3}{4}$ h; and of the moon about the earth in 27d. 7h. 43'; compared with the mean distance of Venus from the sun, and with the greatest heliocentric elongations of the outmost circumjovial satellite from Jupiter's centre, 8' 16"; of the Huygenian satellite from the centre of Saturn, 3' 4"; and of the moon from the earth, 10' 33"; by computation our author found, that the weight of equal bodies, at equal distances from the centres of the sun, of Jupiter, of Saturn, and of the earth, towards the sun, Jupiter, Saturn, and the earth, were one to another as $\frac{1}{10607}$, $\frac{1}{5011}$, and $\frac{1}{100185}$ respectively. Then, because as the distances are increased or diminished, the weights are diminished or increased in a duplicate ratio; the weights of equal bodies towards the sun, Jupiter, Saturn, and the earth, at the distances 10000, 997, 791, and 109, from their centres, that is, at their very superficies, will be as 10000, 943, 529, and 435 respectively.

COR. 2. Hence likewise we discover the quantity of matter in the several planets. For their quantities of matter are as the forces of gravity at equal distances from their centres, that is, in the sun, Jupiter, Saturn, and the earth, as 1, $\frac{1}{1067}$, $\frac{1}{811}$, and $\frac{1}{10918}$ respectively. If the parallax of the sun be taken greater or less than $10'' 30''$, the quantity of matter in the earth must be augmented or diminished in the triplicate of that proportion.

COR. 3. Hence also we find the densities of the planets. For (by prop. 72. book 1.) the weights of equal and similar bodies towards similar spheres, are, at the surfaces of those spheres, as the diameters of the spheres. And therefore the densities of dissimilar spheres are as those weights applied to the diameters of the spheres. But the true diameters of the sun, Jupiter, Saturn, and the earth, were one to another as 10000, 997, 791, and 109; and the weights towards the same, as 10000, 943, 529, and 435 respectively; and therefore their densities are as 100, $94\frac{1}{2}$, 67, and 400. The density of the earth, which comes out by this computation, does not depend upon the parallax

of the sun, but is determined by the parallax of the moon, and therefore is here truly defined. The sun therefore is a little denser than Jupiter, and Jupiter than Saturn, and the earth four times denser than the sun; for the sun, by its great heat, is kept in a sort of a rarefied state. The moon also is denser than the earth.

COR. 4. The smaller the planets are, they are, *cæteris paribus*, of so much the greater density. For so the powers of gravity on their several surfaces come nearer to equality. They are likewise, *cæteris paribus*, of the greater density as they are nearer to the sun. So Jupiter is more dense than Saturn, and the earth than Jupiter. For the planets were to be placed at different distances from the sun, that, according to their degrees of density, they might enjoy a greater or less proportion of the sun's heat. Our water, if it were removed as far as the orb of Saturn, would be converted into ice, and in the orb of Mercury would quickly fly away in vapour. For the light of the sun, to which its heat is proportional, is seven times denser in the orb of Mercury than with us: and by the thermometer Sir Isaac found, that a sevenfold heat of our summer-sun will make water boil. Nor are we to doubt, that the matter of Mercury is adapted to its heat, and is therefore more dense than the matter of our earth; since, in a denser matter, the operations of nature require a stronger heat.

It is shown in the scholium of prop. 22. book 2. of the *Principia*, that, at the height of 200 miles above the earth, the air is more rare than it is at the superficies of the earth, in the ratio of 30 to 0,0000000000003998, or as 75000000000000 to 1 nearly. And hence the planet Jupiter, revolving in a medium of the same density with that superior air, would not lose by the resistance of the medium the 1000000th part of its motion in 1000000 years. In the spaces near the earth, the resistance is produced only by the air, exhalations, and vapours. When these are carefully exhausted by the air-pump from under the receiver, heavy bodies fall within the receiver with perfect freedom, and without the least sensible resistance; gold itself, and the lightest down, let fall together, will descend with equal velocity; and though they fall through a space of four, six, and eight feet, they will come to the bottom at the same time; as appears from experiments that have often been made. And therefore the celestial regions being perfectly void of air and exhalations, the planets and comets meeting no sensible resistance in those spaces, will continue their motions through them for an immense space of time.

NEWTON (Richard) D. D. the founder of Hertford college, is a man of whom we regret that we can give but a superficial and rather a vague account. By one writer he is said to have been a Northamptonshire gentleman; by another, we are told that his father enjoyed at Lavendon Grange in Bucks a moderate estate, which is still in the family, though he lived in a house of Lord Northampton's in Yardley-Chace, where in 1675 our doctor was born. All agree that the family from which he sprung had long been respectable, though its fortunes had been much injured during the great rebellion.

The subject of this article was educated at Westminster school, and from that foundation elected to a studentship of Christ-church, Oxford. At what age

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he was admitted into the university we have no certain information; but in the list of graduates he is thus distinguished: "Newton (Richard,) Christ-church, M. A. April 12th 1701; B. D. March 18th 1707; Hart-hall, D. D. December 7th 1710." He was appointed a tutor in Christ-church as soon as he was of the requisite standing in his college, and discharged the duties of that important office with honour to himself and advantage to the society of which he was a member. From Oxford he was called (we know not at what precise period) into Lord Pelham's family to superintend the education of the late duke of Newcastle and his brother Mr Pelham; and by both these illustrious persons he was ever remembered with the most affectionate regard. In 1710 he was by Dr Aldrich, the celebrated dean of Christ-church, inducted principal of Hart-hall, which was then an appendage to Exeter college. From this state of dependance Dr Newton wrestled it against much opposition, especially from the learned Dr Conybeare, afterwards dean of Christ-church and bishop of Bristol. In no contest, it has been observed, were ever two men more equally matched; and the papers that passed between them, like Junius's letters, deserved to be collected for the energetic beauty of their style and the ingenuity of their arguments. Dr Newton, however, proved successful; and in 1740 obtained a charter, converting Hart-hall into Hertford college; of which, at a considerable expence to himself, and with great aid from his numerous friends, he was thus the founder and first head.

Though this excellent man was Mr Pelham's tutor, and, if report be true, had by him been more than once employed to furnish king's speeches, he never received the smallest preferment from his pupil when first minister: and when that statesman was asked, why he did not place in a proper station the able and meritorious Dr Newton? his reply was, "How could I do it? he never asked me." He was not, however, neglected by all the great. Dr Compton, bishop of London, who had a just sense of his merits, had, at an early period of his life, collated him to the rectory of Sudbury in the county of Northampton, which he held together with the headship of Hart-hall. He resided for some years on that living, and discharged all the parts of his office with exemplary care and fidelity. Amongst other particulars he read the prayers of the liturgy in his church at seven o'clock in the evening of every week-day (hay-time and harvest excepted), for the benefit of such of his parishioners as could then assemble for public devotion. When he left the place, returning again to Oxford about 1724, he enjoined his curates to observe the same pious practice; and was fortunate enough to have three successively who trode in the steps of their worthy principal. Being always an enemy to pluralities with cure of souls, he exerted his utmost endeavours from time to time with Dr Gibson, Bishop Compton's successor in the see of London, for leave to resign his rectory in favour of his curate. To the resignation his lordship could have no objection; but being under some kind of engagement to confer the living on another, Dr Newton retained it himself, but bestowed all the emoluments upon works of charity in the parish, and curates who so faithfully discharged their duty. Dr Sherlock, who succeeded Bishop Gibson, being under

no engagement of a like nature, very readily granted Dr Newton's request, by accepting his resignation, and collating to the rectory Mr Saunders, who was the last of his curates. Upon a vacancy of the public orator's place at Oxford, the head of Hertford college offered himself a candidate; but as the race is not always to the swift nor the battle to the strong, Dr Digby Coates carried the point against him. He was afterwards promoted to a canonry of Christ-church, but did not long enjoy it; for in April 1753 death deprived the world of this excellent man in the 78th year of his age.

He was allowed to be as polite a scholar, and as accomplished a gentleman, as almost any of the age in which he lived. In closeness of argument, and perspicuity of style, he had no superior. Never was any private person employed in more trusts, nor were trusts ever discharged with greater integrity. He was a zealous friend to religion, the university, the clergy, and the poor; and such was his liberality of sentiment, that he admitted to his friendship every man, whatever might be his religious creed, who was earnestly employed in the same good works with himself—the promotion of virtue and unaffected piety. Of his works we have seen only his *Theophrastus*, which was published after his death; and his *Pluralities Indefensible*; but he published several other things during his life, and left a volume of sermons prepared for the press at his death.

NEWTON (Thomas), late lord bishop of Bristol and dean of St Paul's, London, was born on the first of January 1704. His father, John Newton, was a considerable brandy and cyder merchant, who, by his industry and integrity, having acquired what he thought a competent fortune, left off trade several years before he died.

He received the first part of his education in the free school of Litchfield; a school which, the bishop observes with some kind of exultation, had at all times sent forth several persons of note and eminence; from Bishop Smalldridge and Mr Wollaston, to Dr Johnson and Mr Garrick.

From Litchfield he was removed to Westminster school, in 1717, under the care of Dr Friend and Dr Nicoll.

During the time he was at Westminster, there were, he observes, more young men who made a distinguished figure afterwards in the world, than perhaps at any other period, either before or since. He particularly mentions William Murray, the late earl of Mansfield, with whom he lived on terms of the highest friendship to the last.

He continued six years at Westminster school, five of which he passed in the college. He afterwards went to Cambridge, and entered at Trinity college. Here he constantly resided eight months at least in every year, till he had taken his Bachelor of Arts degree. Being chosen Fellow of his college, he came afterwards to settle in London. As it had been his inclination from a child, and as he was also designed for holy orders, he had sufficient time to prepare himself, and composed some sermons, that he might have a stock in hand when he entered on the ministry. His title for orders was his fellowship; and he was ordained deacon in December 1729, and priest in the February following, by Bishop Gibson.

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At his first setting out in his office, he was curate at St George's, Hanover-square; and continued for several years assistant-preacher to Dr Trebeck. His first preferment was that of reader and afternoon-preacher at Grosvenor chapel, in South-Audley street.

This introduced him to the family of Lord Tyrconnel, to whose son he became tutor. He continued in this situation for many years, very much at his ease, and on terms of great intimacy and friendship with lord and lady Tyrconnel, "without so much (says he) as an unkind word or a cool look ever intervening."

In the spring of 1744, he was, through the interest of the earl of Bath (who was his great friend and patron, and whose friendship and patronage were returned by grateful acknowledgments and the warmest encomiums), presented to the rectory of St Mary le Bow; so that he was 40 years old before he obtained any living.

At the commencement of 1745, he took his doctor's degree. In the spring of 1747 he was chosen lecturer of St George's, Hanover square, by a most respectable vestry of noblemen and gentlemen of high distinction. In August following he married his first wife, the eldest daughter of Dr Trebeck; an unaffected, modest, decent young woman, with whom he lived very happy in mutual love and harmony near seven years.

In 1749 he published his edition of Milton's *Paradise Lost*, which (says he, very modestly) it is hoped hath not been ill received by the public, having, in 1775, gone through eight editions. After the *Paradise Lost*, it was judged (says he) proper that Dr Newton should also publish the *Paradise Regained*, and other poems of Milton; but these things he thought detained him from other more material studies, though he had the good fortune to gain by them more than Milton did by all his works put together. But his greatest gain (he says) was their first introducing him to the friendship and intimacy of two such men as Bishop Warburton and Dr Jortin, whose works will speak for them better than any private commendation.

In 1754 he lost his father, at the age of 83; and within a few days his wife, at the age of 38. This was the severest trial he ever underwent, and almost overwhelmed him. At that time he was engaged in writing his *Dissertations on the Prophecies*; and happy it was for him: for in any affliction he never found a better or more effectual remedy than plunging deep into study, and fixing his thoughts as intensely as he possibly could upon other subjects. The first volume was published the following winter; but the other did not appear till three years afterwards; and as a reward for his past and an incitement to future labours, he was appointed, in the mean time, to preach the Boyle's lecture. The bishop informs us, that 1250 copies of the *Dissertations* were taken at the first impression, and 1000 at every other edition: and "though (says he) some things have been since published upon the same subjects, yet they still hold up their head above water, and having gone through five editions, are again prepared for another. Abroad, too, their reception hath not been unfavourable, if accounts from thence may be depended upon." They were translated into the German and Danish languages; and received the warmest encomiums from persons of learning and rank.

In the spring of 1757, he was made prebendary of

Westminster, in the room of Dr Green, and promoted to the deanry of Salisbury. In October following, he was made sub-almoner to his majesty. This he owed to Bishop Gilbert. He married a second wife in September 1761. She was the widow of the Rev. Mr Hand, and daughter of John Lord-Viscount Lisburn. In the same month he kissed his majesty's hand for his bishopric.

In the winter of 1764, Dr Stone, the primate of Ireland, died. Mr Grenville sent for Bishop Newton, and in the most obliging manner desired his acceptance of the primacy. Having maturely weighed the matter in his mind, he declined the offer.

In 1768 he was made dean of St Paul's. His ambition was now fully satisfied; and he firmly resolved never to ask for any thing more.

From this time to his death, ill health was almost his constant companion. It was wonderful that such a poor, weak, and slender thread as the bishop's life, should be spun out to such an amazing length as it really was. In the autumn of 1781 (usually the most favourable part of the year to him) he laboured under repeated illnesses; and on Saturday the 9th of February 1782, he began to find his breath much affected by the frost. His complaints grew worse and worse till the Thursday following. He got up at five o'clock, and was placed in a chair by the fire; complained to his wife how much he had suffered in bed, and repeated to himself that portion of the Psalms, "O my God, I cry unto thee in the day-time," &c. &c. About six o'clock he was left by his apothecary in a quiet sleep. Between seven and eight he awoke, and appeared rather more easy, and took a little refreshment. He continued dozing till near nine, when he ordered his servant to come and dress him, and help him down stairs. As soon as he was dressed, he inquired the hour, and bid his servant open the shutter and look at the dial of St Paul's. The servant answered, it was upon the stroke of nine. The bishop made an effort to take out his watch, with an intent to set it; but sunk down in his chair, and expired without a sigh or the least visible emotion, his countenance still retaining the same placid appearance which was so peculiar to him when alive. Of his numerous works, his *Dissertations on the Prophecies* are by much the most valuable. His learning was undoubtedly very considerable; but he seldom exhibits evidence of a very vigorous mind. On one occasion, indeed, he appears to have thought with freedom; for we believe he was the first dignitary of the church of England who avowed his belief of the final restitution of all things to harmony and happiness.

NEWTYA, a port little known, on the coast between Goa, the capital of the Portuguese settlements in India, and the English settlement of Bombay. Mr Rennel conjectures it to be the *Nitrias* of Pliny; near which the pirates cruized for the Roman ship. The same writer places it near to 15° 52' 30" North Latitude, and 73° 16' 30" East Longitude.

NEXI, among the Romans, persons free-born, who for debt were reduced to a state of slavery. By the laws of the twelve tables it was ordained, that insolvent debtors should be given up to their creditors to be bound in fetters and cords, whence they were called *Nexi*; and though they did not entirely lose the rights

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Neyrecht of freemen, yet they were often treated more harshly than the slaves themselves. If any one was indebted to several persons, and could not within sixty days find a cautioner, his body according to some, but according to others his effects, might be cut in pieces, and divided among his creditors. This latter opinion seems by much the most probable, as Livy mentions a law by which creditors had a right to attach the goods but not the persons of their debtors.

NEYTRECHT, a town of Upper Hungary, capital of a county of the same name, with a bishop's see; seated on the river *Neitra*, 40 miles north-east of Presburg. E. Long. 17. 49. N. Lat. 48. 28.

NGAN-KING-FOU, a city of China, and capital of the western part of the province of Kiang-nan. It is governed by a particular viceroy, who keeps a large garrison in a fort built on the banks of the river Yang-tse-kiang. Its situation is delightful; its commerce and riches render it very considerable; and every thing that goes from the southern part of China to Nan-king must pass through it. All the country belonging to it is level, pleasant, and fertile. It has under its jurisdiction only six cities of the third class.

NGO-KIA, a Chinese drug, of which the composition will no doubt appear as singular as the numerous properties ascribed to it. In the province Chang tong, near Ngo-hien, a city of the third class, is a well, formed by nature, which is reckoned to be seventy feet in depth, and which has a communication, as the Chinese say, with some subterranean lake, or other large reservoir. The water drawn from it is exceedingly clear, and much heavier than common; and if it be mixed with muddy water, it purifies it, and renders it limpid, by precipitating all its impurities to the bottom of the vessel. This water is employed in making the ngo-kia, which is nothing else but a kind of glue procured from the skin of a black ass.

The animal is killed and flayed, and the skin is steeped for five days in water drawn from this well. At the end of that time, it is taken out to be scraped and cleaned; it is afterwards cut into small pieces, which are boiled over a slow fire, in the same kind of water, until it is reduced to a jelly, which is strained, while warm, through a cloth, to free it from all the gross matter which could not be melted. When this glue is cool, and has acquired a consistence, it is formed into square cakes, upon which the Chinese imprint characters and coats of arms, or the signs of their shops.

This well is the only one of the kind in China; it is always shut, and sealed by the governor of the place with his own seal, until the customary day of making the emperor's glue. This operation generally lasts from the autumnal harvest till the month of March. During that time, the neighbouring people and merchants treat for the purchase of the glue with those who guard the well, and with the people who make it. The latter manufacture as much of it as they can, on their own account, with this difference, that it is not so pure, and that they are less scrupulous in examining whether the ass be fat, or of a very black colour: however, all the glue made here is as much esteemed at Peking as that which the mandarins who are on the spot transmit to court and to their friends.

As this drug is in the greatest request, and as the

quantity of it made at Ngo-hien is not sufficient to supply the whole empire, there are not wanting people who counterfeit it elsewhere, and who manufacture a spurious kind from the skins of mules, horses, and camels, and sometimes even from old boots: it is, however, very easy to distinguish that which is genuine; it has neither a bad smell nor a disagreeable taste when applied to the mouth; it is brittle and friable, and always of a deep black colour, sometimes inclining to red. The qualities of the counterfeit kind are entirely different; both its taste and smell are disagreeable, and it is viscous and flabby even when made of the skin of a hog, which is that which imitates the true kind the best.

The Chinese attribute a great number of virtues to this drug. They assure us that it dissolves phlegm, facilitates the play and elasticity of the lungs, gives a free respiration to those who breathe with difficulty; that it comforts the breast, increases the blood, stops dysenteries, provokes urine, and strengthens children in the womb. Without warranting the truth of all these properties, it appears, at least, certain, by the testimony of the missionaries, that this drug is serviceable in all diseases of the lungs. It is taken with a decoction of simples, and sometimes in powder, but very seldom.

NIAGARA, a fort of North America, which was taken from the French 1759, and still remains in possession of the British government. To the author of the American Geography this seems to give great offence; probably because the fort in a manner commands all the interior parts of the continent; is a key to the north-western territories of the united states; and is surrounded by *Six Nations* of Indians, with whom the English have been long in alliance. It is situated on a small peninsula formed by the river Niagara as it flows into the lake Ontario. About six leagues from the fort is the greatest cataract in the world, known by the name of the *Waterfall of Niagara*. The river at this fall runs from SSE to NNW; and the rock of the fall crosses it not in a right line, but forms a kind of figure like an hollow semicircle or horse-shoe. Above the fall, in the middle of the river, is an island about 800 or 1000 feet long; the lower end of which is just at the perpendicular edge of the fall. On both sides of this island runs all the water that comes from the lakes of Canada; viz. Lake Superior, Lake Michigan, Lake Huron, and Lake Erie, which have some large rivers that open themselves into them. Before the water comes to this island, it runs but slowly compared with its motion afterwards, when it grows the most rapid in the world, running with a surprising swiftness before it comes to the fall. It is perfectly white, and in many places is thrown high up into the air. The water that runs down on the west side is more rapid, in greater abundance, and whiter, than that on the east side; and seems almost to outfly an arrow in swiftness. When you are at the fall, and look up the river, you may see that the water is every where exceedingly steep, almost like the side of an hill; but when you come to look at the fall itself, it is impossible to express the amazement it occasions. The height of it, as measured by mathematical instruments, is found to be exactly 137 feet; and when the water is come to the bottom, it jumps back to a very great

Niagara. great height in the air. The noise may be heard at the distance of 45 miles, but seldom further; nor can it be heard even at Fort Niagara, which is only six leagues distant, unless Lake Ontario is calm. At that fort it is observed, that when they hear the noise of the fall more loud than ordinary, they are sure that a north-east wind will follow; which is the more surprising, as the fort lies south-west from the fall. At some times the fall makes a much greater noise than at others; and this is held for an infallible sign of approaching rain or other bad weather.

From the place where the water falls there arises abundance of vapour like very thick smoke, inasmuch that when viewed at a distance you would think that the Indians had set the forests on fire. These vapours rise high in the air when it is calm, but are dispersed by the wind when it blows hard. If you go into this vapour or fog, or if the wind blows it on you, it is so penetrating, that in a few moments you will be as wet as if you had been under water. Some are of opinion that when birds come flying into this fog or smoke of the fall, they drop down and perish in the water; either because their wings are become wet, or that the noise of the fall astonishes them, and they know not where to go in the darkness: but others think that seldom or never any bird perishes there in that manner; because among the abundance of birds found dead below the fall, there are no other sorts than such as live and swim frequently in the water; as swans, geese, ducks, water-hens, teal, and the like. And very often great flocks of them are seen going to destruction in this manner: they swim in the river above the fall, and so are carried down lower and lower by the water; and as water-fowl commonly take great delight in being carried with the stream, they indulge themselves in enjoying this pleasure so long, till the swiftness of the water becomes so great, that it is no longer possible for them to rise, but they are driven down the precipice and perish. They are observed, when they draw nigh the fall, to endeavour with all their might to take wing and leave the water; but they cannot. In the months of September and October such abundant quantities of dead water-fowl are found every morning below the fall, on the shore, that the garrison of the fort for a long time live chiefly upon them. Besides the fowl, they find also several sorts of dead fish, also deer, bears, and other animals which have tried to cross the water above the fall: the larger animals are generally found broken to pieces. Just below, a little way from the fall, the water is not rapid, but goes all in circles, and whirls like a boiling pot; which however does not hinder the Indians going upon it in small canoes a-fishing; but a little further, and lower, the other smaller falls begin. When you are above the fall, and look down, your head begins to turn; even such as have been here numberless times, will seldom venture to look down, without at the same time keeping fast hold of some tree with one hand.

It was formerly thought impossible for any body living to come at the island that is in the middle of the fall: but an accident that happened about 50 years ago made it appear otherwise. The history is this: Two Indians of the Six Nations went out from Niagara fort to hunt upon an island that is in the

Niagara. middle of the river, or strait, above the great fall, on which there used to be abundance of deer. They took some French brandy with them from the fort, which they tasted several times as they were going over the carrying-place; and when they were in their canoe, they took now and then a dram, and so went along up the strait towards the island where they proposed to hunt; but growing sleepy, they laid themselves down in the canoe, which getting loose drove back with the stream, farther and farther down, till it came nigh that island that is in the middle of the fall. Here one of them, awakened by the noise of the fall, cries out to the other, that they were gone: Yet they tried if possible to save life. This island was nighest, and with much working they got on shore there. At first they were glad; but when they had considered every thing, they thought themselves hardly in a better state than if they had gone down the fall, since they had now no other choice, than either to throw themselves down the same, or perish with hunger. But hard necessity put them on invention. At the lower end of the island the rock is perpendicular, and no water is running there. The island has plenty of wood; they went to work then, and made a ladder or shrouds of the bark of the lind-tree (which is very tough and strong) so long till they could with it reach the water below; one end of this bark-ladder they tied fast to a great tree that grew at the side of the rock above the fall, and let the other end down to the water. So they went down along their new-invented stairs, and when they came to the bottom in the middle of the fall they rested a little; and as the water next below the fall is not rapid, as before-mentioned, they threw themselves out into it, thinking to swim on shore. We have said before, that one part of the fall is on one side of the island, the other on the other side. Hence it is, that the waters of the two cataracts running against each other, turn back against the rock that is just under the island. Therefore, hardly had the Indians begun to swim, before the waves of the eddy threw them down with violence against the rock from whence they came. They tried it several times, but at last grew weary; and by being often thrown against the rock they were much bruised, and the skin torn off their bodies in many places. So they were obliged to climb up stairs again to the island, not knowing what to do. After some time they perceived Indians on the shore, to whom they cried out. These saw and pitied them, but gave them little hope or help: yet they made haste down to the fort, and told the commandant where two of their brothers were. He persuaded them to try all possible means of relieving the two poor Indians; and it was done in the following manner:

The water that runs on the east side of this island is shallow, especially a little above the island towards the eastern shore. The commandant caused poles to be made and pointed with iron; two Indians took upon them to walk to this island by the help of these poles, to save the other poor creatures, or perish themselves. They took leave of all their friends, as if they were going to death. Each had two such poles in his hands, to set to the bottom of the stream, to keep them steady; and in this manner reached the island: and having given poles to the two poor negroes there, they

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all returned safely to the main land. These two Indians (who in the abovementioned manner were first brought to this island) were nine days on the island, and almost ready to starve to death. Now since the road to this island has been found, the Indians go there often to kill deer, which have tried to cross the river above the fall, and are driven upon it by the stream. On the west side of this island are some small islands or rocks, of no consequence. The east side of the river is almost perpendicular, the west side more sloping. In former times, a part of the rock at the fall which is on the west side of the island, hung over in such a manner, that the water which fell perpendicularly from it left a vacancy below, so that people could go under between the rock and the water; but the prominent part some years since broke off and fell down. The breadth of the fall, as it runs in a semicircle, is reckoned to be about 300 feet. The island is in the middle of the fall, and from it the water on each side is almost the same breadth; the breadth of the island at its lower end is about 100 feet. Below the fall, in the holes of the rocks, are great plenty of eels, which the Indians and French catch with their hands without any other means. Every day when the sun shines, you see here from ten o'clock in the morning to two in the afternoon, below the fall, and under you, where you stand at the side of the fall, a glorious rainbow, and sometimes two, one within the other. The more vapours, the brighter and clearer is the rainbow. When the wind carries the vapours from that place, the rainbow is gone, but appears again as soon as new vapours come. From the fall to the landing above it, where the canoes from Lake Erie put ashore (or from the fall to the upper end of the carrying-place), is half a mile. Lower the canoes dare not come, lest they should be obliged to try the fate of the two Indians, and perhaps with less success. They have often found below the fall pieces of human bodies, perhaps drunken Indians, that have unhappily come down to the fall. The French say, that they have often thrown whole great trees into the water above, to see them tumble down the fall: they went down with surprising swiftness, but could never be seen afterwards; whence it was thought there was a bottomless deep or abyss just under the fall. The rock of the fall consists of a grey limestone.

Having mentioned the *Six Nations* which live on the banks of the Niagara, we shall here, in addition to what we have said elsewhere (see AMERICA, n^o 17.), subjoin a few particulars relative to those nations, which, as they seem not to be well understood even in America, are probably still less known in Europe. The information which we have to give was communicated to the Royal Society of London by Mr Richard M'Causland surgeon to the 8th regiment of foot, who, writing from the best authority, informs us, that each nation is divided into three tribes, of which the principal are called the *turtle-tribe*, the *wolf-tribe*, and the *bear-tribe*.

Each tribe has two, three, or more chiefs, called *sachems*; and this distinction is always hereditary in the family, but descends along the female line: for instance, if a chief dies, one of his sister's sons, or one of his own brothers, will be appointed to succeed

N^o 242.

him. Among these no preference is given to proximity or primogeniture; but the sachem, during his lifetime, pitches upon one whom he supposes to have more abilities than the rest; and in this choice he frequently, though not always, consults the principal men of the tribe. If the successor happens to be a child, the offices of the post are performed by some of his friends until he is of sufficient age to act himself.

Each of these posts of sachem has a name which is peculiar to it, and which never changes, as it is always adopted by the successor; nor does the order of precedence of each of these names or titles ever vary. Nevertheless, any sachem, by abilities and activity, may acquire greater power and influence in the nation than those who rank before him in point of precedence; but this is merely temporary, and dies with him.

Each tribe has one or two chief warriors; which dignity is also hereditary, and has a peculiar name attached to it.

These are the only titles of distinction which are fixed and permanent in the nation; for although any Indian may by superior talents, either as a counselor or as a warrior, acquire influence in the nation, yet it is not in his power to transmit this to his family.

The Indians have also their great women as well as their great men, to whose opinions they pay great deference; and this distinction is also hereditary in families. They do not sit in council with the sachems, but have separate ones of their own.—When war is declared, the sachems and great women generally give up the management of public affairs into the hands of the warriors. It may however so happen, that a sachem may at the same time be also a chief warrior.

Friendships seem to have been instituted with a view towards strengthening the union between the several nations of the confederacy; and hence friends are called the *sinews of the Six Nations*. An Indian has therefore generally one or more friends in each nation. Besides the attachment which subsists during the lifetime of the two friends, whenever one of them happens to be killed, it is incumbent on the survivor to replace him, by presenting to his family either a scalp, a prisoner, or a belt consisting of some thousands of wampum; and this ceremony is performed by every friend of the deceased.

The purpose and foundation of war-parties, therefore, is in general to procure a prisoner or scalp to replace the friend or relation of the Indian who is the head of the party. An Indian who wishes to replace a friend or relation presents a belt to his acquaintance; and as many as choose to follow him accept this belt, and become his party. After this, it is of no consequence whether he goes on the expedition or remains at home (as it often happens that he is a child); he is still considered as the head of the party. The belt he presented to his party is returned fixed to the scalp or prisoner, and passes along with them to the friends of the person he replaces. Hence it happens, that a war-party, returning with more scalps or prisoners than the original intention of the party required, will often give one of these supernumerary scalps or prisoners to another war-party whom they meet

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meet going out; upon which this party, having fulfilled the purpose of their expedition, will sometimes return without going to war.

NICÆA, (anc. geog.), the metropolis of Bithynia; situated on the lake Ascanius, in a large and fertile plain; in compass 16 stadia: first built by Antigonus, the son of Philip, and thence called *Antigonea*; afterwards completed by Lyfimachus, who called it *Nicæa*, after his consort the daughter of Antipater. According to Stephanus, it was originally a colony of the Bottiaei, a people of Thrace, and called *Ancore*; and afterwards called *Nicæa*. Now *Nice* in Asia the Less*. Famous for the first general council.—A second *Nicæa*, (Diodorus Siculus), of Corsica.—A third, of the Hither India, (Arrian); situated on the west side of the Hydaspes, opposite to Buciphale, on the east side.—A fourth *Nicæa*, a town of Liguria, at the Maritime Alps, on the east side of the river Paulon near its mouth, which runs between the Varus and Nicæa, (Mela). A colony of the Massilians, (Stephanus); the last town of Italy to the west. Now *Nizza* or *Nice*, capital of the county of that name, on the Mediterranean.—A fifth, of Locris, (Strabo); a town near Thermopylæ; one of the keys of that pass. It stood on the Sinus Maliacus.

NICAISE (Claude), a celebrated antiquary in the 17th century, was descended of a good family at Dijon, where his brother was proctor-general of the chamber of accounts. Being inclined to the church, he became an ecclesiastic, and was made a canon in the holy chapel at Dijon; but devoted himself wholly to the study and knowledge of antique monuments. Having laid a proper foundation of learning at home, he resigned his canonry, and went to Rome, where he resided many years; and after his return to France, he held a correspondence with almost all the learned men in Europe. Perhaps there never was a man of letters who had so frequent and extensive a commerce with the learned men of his time as the Abbé Nicaise. This correspondence took up a great part of his time, and hindered him from enriching the public with any large works; but the letters which he wrote himself, and those which he received from others, would make a fine and curious *Commercium Epistolicum*. He published a Latin dissertation *De Nummo Pantheon*; An Explication of an Antique Monument found at Guienne, in the diocese of Aach; and A Discourse upon the Form and Figure of the Syrens, which made a great noise. In this tract, following the opinion of Huet bishop of Avranches, he undertook to prove, that they were in reality birds, and not fishes or sea-monsters. He translated into French, from the Italian, a piece of Bellori, containing a description of the pictures in the Vatican, to which he added, A Dissertation upon the Schools of Athens and Parnassus, two of Raphael's pictures. He wrote also a small tract upon the ancient music; and died while he was labouring to present the public with the explanation of that antique inscription, *Minervæ Arpalia*, which was found in the village of Velley, where he died in October 1701, aged 78.

NICANDER of COLOPHON, a celebrated grammarian, poet, and physician, who lived about the 160th Olympiad, 140 years before Christ, in the reign of

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Attalus king of Pergamus, who overcame the Gallo-Greeks. He lived many years in Etolia, of which country he wrote a history. He wrote also many other works, of which only two are now remaining. The one is intitled *Theriaca*, describing in verse the accidents attending wounds made by venomous beasts, with the proper remedies; the other bearing the title of *Alexipharmaca*, wherein he treats poetically of poisons and their antidotes. This Nicander is not to be confounded with Nicander of Thyatira.

NICANDRA, in botany: A genus of the monogynia order, belonging to the decandria class of plants; and in the natural method ranking under the 30th order, *Contortæ*. The calyx is monophyllous and quadripartite: the corolla is monopetalous, tubulated, and parted into 10 *lacinae*: the fruit is an oval berry, which is grooved longitudinally, and contains many small angular seeds. Of this there is only one species, the *amara*, a native of Guiana. The leaves and stalks are bitter, and used by the natives as an emetic and purge.

NICARAGUA, a large river of South America, in a province of the same name, whose western extremity lies within five miles of the South Sea. It is full of dreadful cataracts, and falls at length into the North Sea.

NICARAGUA, a maritime province of South America, in Mexico, bounded on the north by Honduras, on the east by the North sea, on the south-east by Costa Rica, and on the south-west by the South sea; being 400 miles in length from east to west, and 120 in breadth from north to south. It is one of the most fruitful and agreeable provinces in Mexico, and is well watered with lakes and rivers. The air is wholesome and temperate; and the country produces plenty of sugar, cochineal, and fine chocolate. One of the lakes is 200 miles in circumference, has an island in the middle, and, as some say, has a tide. Leon de Nicaragua is the capital town.

NICARIA, an island of the Archipelago, between Samos and Tine, about 50 miles in circumference. A chain of high mountains runs through the middle, covered with wood, and supplies the country with springs. The inhabitants are very poor, and of the Greek communion; however, they have a little wheat, and a good deal of barley, figs, honey, and wax.

NICASTRO, an episcopal town of Italy, in the kingdom of Naples, and in the Farther Calabria; 16 miles south of Cosenza. E. Long. 15. 59. N. Lat. 39. 15.

NICE, an ancient, handsome, and considerable town on the confines of France and Italy, and capital of a county of the same name, with a strong citadel, a bishop's see, and a senate, which is a kind of a democracy. It has been several times taken by the French, and last of all in 1744, but restored after the treaty of Aix-la-Chapelle. It is very agreeably situated, four miles from the mouth of the river Var. 83 miles S. by W. of Turin, and 83 east of Aix. E. Long. 6. 22. N. Lat. 43. 42.

NICE, a county and province in the dominions of the duke of Savoy. The inhabitants supply Genoa with a great deal of timber for building ships; and carry on a great trade in linen-cloth, paper, oil, wine, and honey.—“Although the county of Nice be on

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this side of the mountains, geographers have always considered it as a province of Italy, since they have given to this beautiful part of Italy the river Vard for a western limit, which is also the boundary of the county, and flows into the sea at a league distance from the capital. This province is partly covered by the maritime Alps; and is bordered on the east by Piedmont, and the states of Genoa; on the south by the Mediterranean; on the west by the Vard; and on the north by Dauphiny. Its length is about 20 leagues of the country, which make about 36 English miles; its breadth is 10 leagues; and its population is about 120,000 souls.

"The city of Nice is the capital, and the seat of the senate, the bishopric, and government. It has become, within these few years, a delightful abode, by the number of strangers who assemble there in the winter, either to re-establish their health, or to enjoy the mildness of the climate, and the beauty of the country, where an unceasing verdure presents eternal spring.

"The town is situated on the sea-shore, and is backed by a rock entirely insulated, on which was formerly a castle, much esteemed for its position; but it was destroyed in the year 1706 by Marechal Berwick, the garrison being too thin to defend the extent of the works. There is a distinction between the old and the new town; this last is regular, the houses are well built, and the streets are wide. Its position is by the side of the sea, and it is terminated, on one side, by a charming terrace, which serves for a promenade.

"Any person may live peaceably in this province, without fear of being troubled on points of faith, provided he conduct himself with decorum. The town has three suburbs. 1st, That of St John, which conducts to Cimier, about three leagues north from Nice, &c. The promenades this way are very delightful, and may be enjoyed in a carriage. 2d, That of the Poudriere. 3d, That of the *Croix de Marbre*, or Marble Cross. This suburb is new; and the English almost all lodge in it, being very near the town. The houses are commodious, facing on one side the great road which leads to France, and on the other a fine garden, with a prospect of the sea. All the houses are separate from each other: the company hire them for the season, *i. e.* from October till May. Apartments may be had from 15 to 250 louis. The proprietors commonly furnish linen, plate, &c. There are also in the town very large and commodious houses; as well as the new road, which is opened from the town to the port, by cutting that part of the rock which inclined toward the sea. The situation is delightful, and warmest in winter, being entirely covered from the north wind, and quite open to the south.

"The company is brilliant at Nice, and the amusements of the carnival are, in proportion to the size of the town, as lively as in any of the great ones in France. There is always an Italian opera, a concert, and masked ball, alternately; and the company play rather high.

"It is impossible to find a happier climate than Nice, both for summer and winter. Reaumur's thermometer, in 1781, never fell more than three degrees

below the freezing point, and that only for two days; while at Geneva it fell ten: and in the course of the winter of 1785 it fell only two degrees; while at Geneva it fell 15. The month of May is rarely so fine in France as February at Nice. The summer is not so hot as might be expected. The thermometer never rises more than 24 degrees above temperate in the shade; and there is always an agreeable sea-breeze from ten in the morning till sun-set, when the land-breeze comes on. There are three chains of graduated mountains, the last of which confound their summits with the Alps; and to this triple rampart is owing the mild temperature so sensibly different from the neighbouring parts.

"The cultivation of the ground is as rich as can be desired. There are alternately rows of corn and beans, separated by vines attached to different fruit-trees, the almond and the fig; so that the earth being incessantly cultivated, and covered with trees, olive, orange, cedar, pomegranate, laurel, and myrtle, causes the constant appearance of spring, and forms a fine contrast with the summits of the Alps, in the back-ground, covered with snow."

NICE, an ancient town of Asia, in Natolia, now called *Isnick*, with a Greek archbishop's see. It is famous for the general council assembled here in 325, which endeavoured to suppress the doctrines of Arius. It was formerly a large, populous, and well-built place, and even now is not inconsiderable. See ISNICK.

NICENE Creed, was composed and established, as a proper summary of the Christian faith, by the council at Nice in 325, against the Arians.—It is also called the *Constantinopolitan creed*, because it was confirmed, with some few alterations, by the council of Constantinople in 381. See CREED.

NICEPHORUS (Gregoras), a Greek historian, was born about the close of the 13th century, and flourished in the 14th, under the emperors Andronicus, John Palæologus, and John Cantacuzenus. He was a great favourite of the elder Andronicus, who made him librarian of the church of Constantinople, and sent him ambassador to the prince of Servia. He accompanied this emperor in his misfortunes, and assisted at his death; after which he repaired to the court of the younger Andronicus, where he seems to have been well received; and it is certain that, by his influence over the Greeks, that church was prevailed on to refuse entering into any conference with the legates of pope John XXII. But in the dispute which arose between Barlaam and Palamos, taking the part of the former, he maintained it zealously in the council that was held at Constantinople in 1351, for which he was cast into prison, and continued there till the return of John Palæologus, who released him; after which he held a disputation with Palamos, in the presence of that emperor. He compiled a history, which in 11 books contains all that passed from 1204, when Constantinople was taken by the French, to the death of Andronicus Palæologus the younger, in 1341.—The best edition of this work is that of the Louvre, in Greek and Latin, in 1702.

NICEPHORUS (Calistus), a Greek historian, who flourished in the 14th century under the emperor Andronicus Palæologus the elder, wrote an ecclesiastical history in 23 books; 18 of which are still extant, containing the transactions of the church from the birth of

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Christ to the death of the emperor Phocas in 610. We have nothing else but the arguments of the other five books from the commencement of the reign of the emperor Heraclius to the end of that of Leo the philosopher, who died in the year 911. Nicephorus dedicated his history to Andronicus Palæologus the elder. It was translated into Latin by John Langius; and has gone through several editions, the best of which is that of Paris, in 1630.

NICEPHORUS (Blemmidas), a priest and monk of Mount Athos, flourished in the 13th century. He refused the patriarchate of Constantinople, being favourable to the Latin church, and more inclined to peace than any of the Greeks of his time. In this spirit he composed two treatises concerning *The Procession of the Holy Ghost*: one addressed to James patriarch of Bulgaria, and the other to the emperor Theodore Lascaris. In both these he refutes those who maintain, that one cannot say the Holy Ghost proceeds from the Father and the Son. These two tracts are printed in Greek and Latin by Allatius, who has also given us a letter written by Blemmidas on his expelling from the church of her convent Marchesinos, mistress of the emperor John Ducas. There are several other pieces of our author in the Vatican library.

NICERON (John Francis), was born at Paris in 1613. Having finished his academical studies, with a success which raised the greatest hopes of him, he entered into the order of the Minims, and took the habit in 1632; whereupon, as is usual, he changed the name given him at his baptism for that of Francis, the name of his paternal uncle, who was also a Minim, or Franciscan. The inclination and taste which he had for mathematics appeared early. He began to apply himself to that science in his philosophical studies, and devoted thereto all the time he could spare from his other employments, after he had completed his studies in theology. All the branches of the mathematics, however, did not equally engage his attention; he confined himself particularly to optics, and only learned of the rest as much as was necessary for rendering him perfect in this. There remain still, in several houses wherein he dwelt, especially at Paris, some excellent performances, which discover his skill in this way, and which make us regret that a longer life did not suffer him to carry it to that perfection which he desired; since one cannot help being surprised that he proceeded so far as he did, in the midst of those occupations and travels by which he was forced from it, during the short space of time which he lived. He hath himself observed, in the preface to his *Thaumaturgus Opticus*, that he went twice to Rome; and that, on his return home, he was appointed teacher of theology. He was afterwards chosen to accompany father Francis de la Noue, vicar-general of the order, in his visitation of the convents throughout all France. But the eagerness of his passion for study put him upon making the best of all the moments he had to spare for books; and that

wise œconomy furnished him with as much as satisfied him. Being taken sick at Aix in Provence, he died there Sept. 22. 1646, aged 33. He was an intimate acquaintance of Des Cartes. A list of his writings is inserted below (A).

NICERON (John Peter), so much celebrated on account of his *Memoirs of Men illustrious in the Republic of Letters*, was born at Paris March 11. 1685. He was of an ancient and noble family, who were in very high repute about 1540. He studied with success in the Mazarine college at Paris, and afterwards at the college Du Pleffis. In a short time, resolving to forsake the world, he consulted one of his uncles, who belonged to the order of Bernabite Jesuits. This uncle examined him; and, not dissident of his election, introduced him as a probationer to that society at Paris. He was received there in 1702, took the habit in 1703, and made his vows in 1704, at the age of 19.

After he had professed himself, he was sent to Montarges, to go through a course of philosophy and theology; thence he went to Loches in Touraine to teach those sciences. He received the priesthood at Poitiers in 1708. As he was not arrived at the age to assume this order, a dispensation, which his uncommon piety had merited, was obtained in his favour. The college of Montarges having recalled him, he was their professor of rhetoric two years, and of philosophy four. In spite of all these avocations, he was humanely attentive to every call and work of charity, and to the instruction of his fellow-creatures, many of whom heard him deliver out fit rules of conduct for them, not only from the pulpits of most of the churches within the province, but even from those of Paris.—In 1716, his superiors invited him to that city, that he might have an opportunity of following, with the more convenience, those studies for which he always had expressed the greatest inclination. He not only understood the ancient but the modern languages; a circumstance of infinite advantage in the composition of those works which he has given to the public, and which he carried on with great assiduity to the time of his death, which happened, after a short illness, July 8. 1738, at the age of 53. His works are, 1. *Le grand Febrifuge*; or, a Dissertation to prove, that common water is the best remedy in fevers, and even in the plague; translated from the English of John Hancock minister of St Margaret's, London, in 12mo. This little treatise made its appearance, amongst other pieces relating to this subject, in 1720; and was attended with a success which carried it through three editions; the last came out in 1730, in 2 vols. 12mo, intitled, *A Treatise on Common Water*; Paris, printed by Cavelier. 2. *The Voyages of John Ouwington to Surat, and divers parts of Asia and Africa*, containing the history of the revolution in the kingdom of Golconda, and some observations upon silk-worms; Paris 1725, 2 vols. 12mo. 3. *The Conversion of England to Christianity, compared with its pretended Reformation*, a work translated from

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(A) These are, 1. *L'Interpretation des chiffres, ou regles pour bien entendre & expliquer facilement toutes sortes des chiffres simples, &c.* 2. *La perspective curieuse, ou magie artificielle des effets merveilleux de l'optique, catoprique, & dioptrique.* This is only an essay to the following work: 3. *Thaumaturgus opticus; sive, Admiranda optices, catopricæ, & dioptrices, pars prima, &c.* He intended to add two other parts, but was prevented by death.

Nicetas
Nichols.

the English; Paris 1729, 8vo. 4. *The Natural History of the Earth*, translated from the English of Mr Woodward, by Mons. Nogues, doctor in physic; with an answer to the objections of Dr Carmerarius; containing also several letters written on the same subject, and a methodical distribution of fossils, translated from the English by Niceron; Paris 1735, 4to. 5. *Memoirs of Men illustrious in the Republic of Letters*, with a critical account of their works; Paris, 12mo. The first volume of this great work appeared in 1727; the others were given to the public in succession, as far as the 39th, which appeared in 1738. The 40th volume was published after the death of the author, in 1739.

NICETAS (David), a Greek historian, a native, as some relate, of Paphlagonia, who lived about the end of the 9th century. He wrote *The Life of St Ignatius*, patriarch of Constantinople, which was translated into Latin by Frederic Mutius, bishop of Termoli: he composed also several panegyrics in honour of the apostles and other saints, which are inserted in the last continuation of the *Bibliotheca Patrum* by Combefis.

NICETAS (surnamed SERRON), deacon of the church of Constantinople, cotemporary with Theophylact in the 11th century, and afterwards bishop of Heraclea, wrote a *Catena upon the book of Job*, compiled from passages of several of the fathers, which was printed at London in folio, 1637. We have also, by the same writer, several *catena* upon the Psalms and Canticles, Basil 1552; together with a Commentary on the poems of Gregory Nazianzen.

NICETAS (Arhominates), a Greek historian of the 13th century, called *Coniates*, as being born at Chone, or Colossus, in Phrygia. He was employed in several considerable affairs at the court of Constantinople; and when that city was taken by the French in 1204, he withdrew, with a young girl taken from the enemy, to Nice in Bithynia, where he married his captive, and died in 1206. He wrote a History, or Annals, from the death of Alexius Comnenus in the year 1118, to that of Badouin in 1205; of which work we have a Latin translation by Jerome Wolfius, printed at Basil in 1557; and it has been inserted in the body of the Byzantine Historians, printed in France at the Louvre.

NICHE, in architecture, a hollow sunk into a wall, for the commodious and agreeable placing of a statue. The word comes from the Italian *nechia*, "sea-shell;" in regard the statue is here inclosed in a shell, or perhaps on account of the shell wherewith the tops of some of them are adorned.

NICHOLS (William), son of John Nichols of Donington, in Bucks, was born in 1664. At what school he was educated we have not been informed; but in 1679 he became a commoner of Magdalene Hall, Oxford, whence he afterwards removed to Wadham College, and took the degree of bachelor of arts Nov. 27. 1683.—In October 1684, he was admitted probationer-fellow of Merton College. At the commencement of 1688 he took his master's degree; and about the same time being admitted into orders, he became chaplain to Ralph earl of Montague, and was in September 1791 preferred to the rectory of Selsey; near Chichester, in Suffex. He was admitted B. D. July 2. 1692; and D. D. Nov. 29. 1695. Though his time was wholly devoted to piety and study, and

though he published, in Latin and in English, no fewer than 19 works in defence of Christianity, and the doctrines and worship of the church of England, he was so totally overlooked, even by those who professed to be patrons of orthodoxy, that towards the close of his life we find him complaining to Robert earl of Oxford, that he was forced on the drudgery of being editor of Mr Seldon's books for a little money to buy other books, to enable him to carry on his liturgical labours. He died in the beginning of the year 1712. Of his numerous publications, those which are most generally known are, *A Conference with a Theist*, in five parts, and *A Comment on the Book of Common Prayer and Administration of the Sacraments, &c.* A volume of letters in Latin between him and Joblonski, Ostervald, and Wettstein, &c. was presented, October 28. 1712, by his widow to the archbishop of Canterbury; and they are now preserved among the valuable MSS. at Lambeth, n^o 676.

NICHOLLS (Dr Frank), was born in London in the year 1699. His father was a barrister at law; and both his parents were of good families in Cornwall. After receiving the first rudiments of his education at a private school in the country, where his docility and sweetness of temper endeared him equally to his master and his school-fellows, Frank was in a few years removed to Westminster, and from thence to Oxford, where he was admitted a commoner (or sojourner) of Exeter college, under the tuition of Mr John Haviland, on March 4th 1714. There he applied himself diligently to all the usual academical studies, but particularly to natural philosophy and polite literature, of which the fruits were most conspicuous in his subsequent lectures on physiology. After reading a few books on anatomy, in order to perfect himself in the nomenclature of the animal parts then adopted, he engaged in dissections, and then devoted himself to the study of nature, perfectly free and unbiassed by the opinions of others.

On his being chosen reader of anatomy in that university, he employed his utmost attention to elevate and illustrate a science which had there been long depressed and neglected; and by quitting the beaten track of former lecturers, and minutely investigating the texture of every bowel, the nature and order of every vessel, &c. he gained a high and a just reputation. He did not then reside at Oxford; but, when he had finished his lectures, used to repair to London, the place of his abode, where he had determined to settle. He had once an intention of fixing in Cornwall, and for a short time practised there with great reputation; but being soon tired of the fatigues attendant on that profession in the country, he returned to London, bringing back with him a great insight, acquired by diligent observation, into the nature of the miliary fever, which was attended with the most salutary effects in his subsequent practice at London.

About this time he resolved to visit the continent, partly with a view of acquiring the knowledge of men, manners, and languages; but chiefly to acquaint himself with the opinions of foreign naturalists on his favourite study. At Paris, by conversing freely with the learned, he soon recommended himself to their notice and esteem. Winslow's was the only good system of physiology at that time known in France, and Morgagni's

Nicholls. gagni's and Santorini's of Venice in Italy, which Dr Nicholls likewise soon after visited. On his return to England, he repeated his physiological lectures in London, which were much frequented, not only by students from both the universities, but also by many surgeons, apothecaries, and others. Soon after, his new and successful treatment of the miliary fever, then very prevalent in the southern parts of England, added much to his reputation. In 1725, at a meeting of the Royal Society, he gave his opinion on the nature of *aneurisms*, in which he dissented from Dr Freind in his History of Physic.

At the beginning of the year 1728, he was chosen a fellow of the Royal Society, to which he afterwards communicated the description of an uncommon disorder (published in the Transactions), viz. a polypus, resembling a branch of the pulmonary vein (for which Tulpus has strangely mistaken it), coughed up by an asthmatic person. He also made observations (in the same volume of the Transactions) on a treatise, by M. Helvetius of Paris, on the Lungs. Towards the end of the year 1729, he took the degree of doctor of physic at Oxford. At his return to London, he underwent an examination by the president and censors of the college of physicians, previous to his being admitted a candidate, which every practitioner must be a year before he can apply to be chosen a fellow. Dr Nicholls was chosen into the college on June 26. 1732; and two years after, being chosen Gualstonian reader of Pathology, he made the structure of the heart, and the circulation of the blood, the subject of his lectures. In 1736, at the request of the president, he again read the Gualstonian lecture; taking for his subject those parts of the human body which serve for the secretion and discharge of the urine; and the causes, symptoms, and cure, of the diseases occasioned by the stone. In 1739, he delivered the anniversary Harveian oration. In 1743, he married Elizabeth, youngest daughter of the celebrated Dr Mead, by whom he had five children, two of whom died young. Two sons and a daughter survived him. In 1748, Dr Nicholls undertook the office of surgical lecturer, beginning with a learned and elegant dissertation on the *Anima Medica*. About this time, on the death of Dr John Cuninghame, one of the elects of the college, Dr Abraham Hall was chosen to succeed him, in preference to our author, who was his senior, without any apparent reason. With a just resentment, he immediately resigned the office of surgical lecturer, and never afterwards attended the meetings of the fellows, except when business of the utmost importance was in agitation.

In 1751, he took some revenge in an anonymous pamphlet, intitled "The Petition of the Unborn Babes to the Censors of the Royal College of Physicians of London;" in which Dr Nesbit (*Pocus*), Dr Maule (*Maulus*), Dr Barrowby (*Barebone*), principally, and Sir William Brown, Sir Edward Hulse, and the Scots incidentally, are the objects of his satire.

In 1753, on the death of Sir Hans Sloane, Bart. in his 94th year, Dr Nicholls was appointed to succeed him as one of the king's physicians, and held that office till the death of his royal master in 1760, when this most skilful physician was superseded with some-

thing like the offer of a pension, which he rejected with disdain.

The causes, &c. of the uncommon disorder of which the late king died, viz. a rupture of the right ventricle of the heart, our author explained in a letter to the earl of Macclesfield, president of the Royal Society, which was published in the Philosophical Transactions vol. 1.

In 1772, to a second edition of his treatise *De Anima Medica*, he added a dissertation *De motu cordis et sanguinis in homine nato et non nato*, inscribed to his learned friend and coadjutor the late Dr Lawrence.

Tired at length of London, and also desirous of superintending the education of his son, he removed to Oxford, where he had spent most agreeably some years in his youth. But when the study of the law recalled Mr Nicholls to London, he took a house at Epsom, where he passed the remainder of his life in a literary retirement, not inattentive to natural philosophy, especially the cultivation of grain, and the improvement of barren soils, and contemplating also with admiration the internal nature of plants, as taught by Linnæus.

His constitution never was robust. In his youth, at Oxford, he was with difficulty recovered from a dangerous fever by the skill of Doctors Frampton and Frewen; and afterwards at London he had frequently been afflicted with a catarrh, and an inveterate asthmatic cough, which, returning with great violence at the beginning of the year 1778, deprived the world of this valuable man on January 7th, in the 80th year of his age.

Dr Lawrence, formerly president of the college of physicians, who gratefully ascribed all his physiological and medical knowledge to his precepts, and who, while he lived, loved him as a brother, and revered him as a parent, two years after printed, and gave to his friends, a few copies of an elegant Latin Life of Dr Nicholls (with his head prefixed, a striking likeness, engraved by Hall from a model of Goffet, 1779); from which, through the medium of the Gentleman's Magazine, the above particulars are chiefly extracted.

NICIAS, a celebrated painter of Athens, flourished about 322 years before the Christian era; and was universally extolled for the great variety and noble choice of his subjects, the force and relieve of his figures, his skill in the distribution of the lights and shadows, and his dexterity in representing all sorts of four-footed animals, beyond any master of his time. His most celebrated piece was that of Tartarus or Hell, as it is described by Homer, for which king Ptolemy the son of Lagus offered him 60 talents, or 11,250l. which he refused, and generously presented it to his own country. He was much esteemed likewise by all his cotemporaries for his excellent talent in sculpture.

NICKEL, in chemistry and mineralogy, a substance classed among the semimetals, though several eminent chemists are of opinion that it is a compound; and Mr Bergman, who has made more experiments upon it than any other person, conjectures that it is a modification of iron.

It was first obtained from an ore called *kupfer-nickel*, sometimes

Nicholls

Nickel.

Nickel.

sometimes grey coloured, but often of a reddish-yellow; though several others are now discovered. "It had its name (says Mr Bergman), and probably still retains it, from this circumstance, that though it has the appearance of containing copper, not the smallest particle of that metal can be extracted from it, even by fire." It was first mentioned by V. Hiema, in 1694, in a book written in the Swedish language, concerning the discovery of ores and other mineral substances. It is supposed by Henckel to be a species of cobalt, or arsenic alloyed with copper. Cramer classes it with the arsenical or cupreous ores; though both they and all other chemists confess that they were never able to extract one particle of copper from it. Mr Cronstedt, in the years 1751 and 1754, showed by many accurate experiments that it contained a new semimetal, or at least that a regulus different from all others was obtainable from its ore. This ore, called *kupfer-nickel*, or false copper, as has already been observed, is of a coppery lead colour, and almost always covered with a greenish-grey efflorescence. "It is (says Mr Fourcroy) very common at Freyberg in Saxony, where it is often mixed with the grey ore of cobalt; but it is distinguished from it by its red colour." Mr Bergman, however, complains greatly of the scarcity of this mineral, so that he could hardly procure a quantity sufficient to make experiments upon. Fourcroy also tells us, that "Mr Sage, having treated this ore with sal-ammoniac, obtained iron, copper, and cobalt, and thinks that it is composed of these three metallic matters, together with arsenic. It likewise contains a small proportion of gold, according to this chemist. It is proper to observe, that these results do not agree with those of Mr Bergman; he is said to have operated on the *kupfer-nickel* of Biber, in Hesse, and of Allemont in Dauphiny. Mr Bergman himself, however, informs us, that he undertook his experiments expressly with a view to discover whether the theory of Mr Sage was just; and that he operated mostly on some regulus made by Mr Cronstedt, and found in the Suabian collection.

"Cronstedt (says Mr Fourcroy) assures us, that the metallic matter, called *speiss* by the Germans, which is collected in the crucibles used in the melting of smalt, affords nickel. Mr Monnet thinks, that the *speiss* of the manufacture of Gengenback, 14 leagues from Strasburg, is true nickel: and as the ore of cobalt made use of in that place to make smalt is very pure, he concludes, that nickel is necessarily a product of cobalt itself. But Mr Beaume has obtained nickel from almost all the ores of cobalt by means of sulphur; it therefore seems, that the ore of cobalt, which is wrought at Gengenback, contains nickel not distinguishable by the eye, on account of the intimate union of these two metallic matters."

"To obtain the regulus of nickel (says Mr Bergman), the ore must be first subjected to roasting; during which a quantity of sulphur and arsenic, greater or less according to the nature of the ore, is expelled; so that it sometimes loses above half its weight, but frequently not above 0.3. This ore, though long and completely calcined, does not always acquire the same colour, but in general becomes greener in proportion as it is more rich. Sometimes (especially if suffered to lie at rest) its upper surface is covered with green ve-

getations, somewhat of the form of coral, which are hard and sonorous. A double or triple quantity of black flux is to be added to the roasted powder, and the mixture well fused in a forge in an open crucible covered with common salt, in the usual method. The vessel being broken, a metallic globule is found at the bottom, the weight of which amounts to 0.1, 0.2, or at the most to 0.5 of the crude ore. The regulus thus obtained, however, is far from being pure; for although the roasting be ever so violent and long continued, yet a considerable quantity of sulphur, but especially arsenic, still remains concealed, exclusive of cobalt, and a great proportion of iron; which last is so generally prevalent, as to make the regulus magnetic: and this variety of heterogeneous matter is the cause why the regulus varies much, not only in respect to its fracture, the polished surface of which is either smooth or lamellated, but also in regard to its white colour, which is more or less yellow or red."

He has not been able to determine the properties of nickel when perfectly pure, as the continual presence of iron in some respect obscures them: From the calculations which he makes, however, Mr Bergman concludes, that the specific gravity of nickel is not less than 9.000 at the least. If a small portion of gold enter the composition, the greatness of the weight might thence be explained; but though this metal is almost always absent, yet 36 parts of it, 48 of iron, and one of copper, were formed by fusion into a globe, the specific gravity of which was 8.8571, but was little soluble in nitrous acid; yet after lying about two hours in the acid, the gold was plainly to be seen, and with volatile alkali the menstruum yielded nothing but a ferruginous brown precipitate, which in the fire put on the appearance of calcined iron.

The solutions of nickel in all the acids are green. The vitriolic scarcely attacks the regulus unless by evaporation to dryness. The nitrous acid, by the assistance of heat, dissolves both the calx and the regulus; as does likewise the marine acid, but slowly, and not without the assistance of heat. Acid of arsenic unites with the calx into a green saline mass; but with the regulus it separates a saline powder difficult of fusion. Fluor acid dissolves the calx with difficulty, and forms crystals of a diluted green colour. Acid of borax scarce dissolves nickel directly, but takes it up by a double elective attraction. Vinegar forms with the calx spathose crystals of an intense green colour, which can scarce be decomposed by acid of tartar. The saccharine acid converts both regulus and calx into a white powder, not easily soluble in water. Acid of phosphorus attracts it but little. The acid of ants, by decoction or long digestion, attacks the newly precipitated calx; for the solution is green, and upon evaporation yields crystals of a deep green colour, hemispherical, formed of filaments diverging from a centre, and pellucid. They are not soluble in spirit of wine, and scarcely in water, unless it be acidulated. Lemon-juice seems not to act at all upon nickel. All the acids are deeply tinged by dissolving nickel; and this property belongs to the first regulus as well as that which is most highly depurated. Volatile alkali dissolves it, and the solution is of a blue colour: the fixed alkali dissolves it very sparingly, and forms a yellow solution.

Nickel.

Nickel

Nickel.

Nickel becomes the more difficult of fusion, in proportion to its purity, so that at last it requires nearly as great a heat for this purpose as malleable iron. It is easily melted with other metals, but its great scarcity has prevented this matter from being thoroughly investigated. It may, however, be observed, that the impure regulus cannot be united with silver, which must be attributed to the cobalt it contains; for when well freed from that metal, it easily unites in equal proportions with silver, and that without any remarkable diminution of the whiteness or ductility of the latter. This mixture, fused with borax, tinges it of an hyacinthine colour. Copper unites more slowly with depurated nickel, yielding a red and ductile metallic mass, which tinges borax of a reddish hyacinthine colour. It produces only a brittle mass with tin; in which respect it differs from cobalt. It could not be amalgamated with mercury by trituration.

Nickel, when well depurated, does not easily part with its phlogiston, or, in the language of the new nomenclature, receive an accession of Carbone; for it only assumes a brown colour, and that with great difficulty in the ordinary way of calcination in the assay furnace. By means of nitre, however, it is more completely dephlogisticated, and becomes green. The metallic calx, vitrified with borax, produces an hyacinthine tinge; which yet, if occasioned by a regulus not well depurated, vanishes on continuing the fire, a slight blue tinge being produced by the addition of nitre; but a calx of well depurated regulus of nickel forms a permanent colour. The calx of nickel communicates also an hyacinthine colour to microcosmic salt; which, by long-continued fusion on charcoal, may indeed be weakened, but can hardly be quite discharged. On the addition of nitre it changes to a violet, but becomes again hyacinthine on augmenting the quantity of microcosmic salt. If the calx of nickel be added to saturation, the fused glass assumes a blood-colour; but on being fused, becomes more and more yellow.

Under the article CHEMISTRY, n° 1316, and in the present article, we have observed, that Mr Bergman conjectures nickel to be only a modification of iron. He examines, however, with great care, the opinion of other authors, who suppose it to be composed of arsenic, copper, cobalt, and iron.—“With respect to arsenic (says he) we may very safely exclude it from the number; as experiments show that it may be entirely expelled. It cannot be doubted but that copper is present in some ores of nickel, and therefore may easily be mixed with the regulus; but the greater number are entirely without it. It is true, that nickel is totally soluble in volatile alkali, and that this solution is of a blue colour; but if this argument held good, there would be nothing found here but copper; in which case very different phenomena would take place from those which are produced by nickel. The blue colour, produced both by copper and nickel, can no more prove their identity than the yellow colour produced both by gold and iron, when dissolved in aqua regia, can prove the identity of these two metals. Nickel and copper agree also in this property, that they are both precipitated from acids and from volatile alkali by iron; but a considerable difference appears in the manner in which this precipitation is accomplished. When a polished piece of iron is put into a solution of nickel, a yellow pellicle of the latter will by degrees adhere to it; but

this soon disappears on touching, and grows black, unless the acid be well saturated, or sufficiently diluted with water. A similar precipitation is observed if zinc be made use of instead of iron; but in solution of copper so much diluted, that the precipitation on iron may be nearly similar to that of nickel, zinc is immediately covered with a crust of the colour of mountain brass.”

An invincible argument that cobalt is no essential ingredient in nickel is, that a solution of the latter in hepatic sulphur is precipitated by the former. In the same way nickel tinging borax, or the microcosmic salt, in the dry way, is thrown down by the addition of a proper quantity of copper; but this is not the case with cobalt. A remarkable difference likewise occurs with all the acids. 1. Cobalt tinges all these menstrua of a red colour, yielding crystals either of a yellow or bluish red. But nickel produces solutions and concretions of a fine green: it sometimes happens, indeed, that the red solutions yield greenish crystals; but this is to be attributed to nickel in small proportion mixed with the cobalt. 2. Cobalt united with the marine acid yields sympathetic ink, but depurated nickel does not. 3. Cobalt, dissolved in volatile alkali, affords a red solution, but nickel dissolved in the same alkali is blue. 4. Cobalt does not, like nickel, separate, on the addition of arsenical acid, a powder difficult of solution. Iron therefore only remains; and indeed, says Mr Bergman, there are many and weighty reasons, which induce us to think that nickel, cobalt, and manganese, are perhaps to be considered in no other light than modifications of iron.

1. Unequal portions of phlogiston, united to the same iron, or, according to the new nomenclature, iron containing different proportions of carbone, changes its qualities in a remarkable manner: for instance, how very much do the different kinds of iron and steel differ? It is then to be observed, that nickel, cobalt, and manganese, whatever operations they may be subjected to, are so far from being deprived of iron, that, on the contrary, they thereby become more ductile, magnetic, and refractory. Again, the various colours which nickel, cobalt, and manganese exhibit, both by solution and by fire, are also exhibited by iron. Cobalt and manganese occasion a red colour in acids, and the latter in glass; nickel and manganese occasion an hyacinthine colour when fused with borax; a green is produced in acids by nickel, as also by its calx, and by manganese when long and strongly calcined; and it often leaves behind a scoria of the same colour, if the reduction be performed with a saline flux. Lastly, Cobalt occasions a blue or rather violet colour in glass; and the same is true of manganese dissolved in fixed, and of nickel in volatile, alkali. Iron exhibits all these varieties; for the acids form with this metal solutions of a green colour as long as it contains a certain quantity of phlogiston; but in proportion to the diminution of this principle, a yellow, red, or brownish red, colour is produced. It tinges glass in the same manner, green, yellow, black, or red. Exposed to the fire for many hours together with nitre, blue, greenish blue, or greenish purple flowers, indeed are transmitted through the crucible; but an efflorescence of the same kind is produced by nitre alone, which, by long continued fire, penetrates the vessels, and is decomposed by the contact of the burning fuel, the alkaline efflorescences

Nickel.

Nickel,
Nicobar.

rescences being made blue by the manganese, which is always present in the circumjacent ashes; and these verge more to a green in proportion as the crocus martis is more copious; besides, iron itself is often found mixed with manganese. Hence therefore it appears, that the blue flowers which are expelled from nickel by means of nitre are the produce of manganese, as these impart to glass nothing of the cobalt colour; besides, in the mineral kingdom, we find the nephritic stones, and many others of blue, yellow, red, and green colours, all proceeding from iron alone.

The ores already mentioned, from which nickel has been obtained, are as follow:

1. Mr Rinman asserts, that it has been found native in a mine of cobalt in Hesse. It is very heavy, and of a liver colour or dark red. When pulverised, and roasted under a muffle, it forms green excrescences, and smokes; but its smoke has no particular smell, nor can any sublimate, either sulphureous or arsenical, be caught. It is soluble in acids, and the solution is green, but a polished iron plate discovers no copper.

2. Aerated nickel is found in form of a calx, and is commonly mixed with the calx of iron; in which case it has the name of *nickel-ochre*. This is green, and is found in form of flowers on *kupfer-nickel*. It has been found in Sweden, without any visible quantity of nickel in its composition, in clay which contained much silver.

3. *Kupfer-nickel* is of a reddish yellow bright colour, as has already been mentioned, and its texture is either uniform, granular, or scaly. It is bright when broken, very heavy, and generally covered with a greenish efflorescence. By calcination it loses much of its sulphur, and becomes green, forming fungous ramifications. Mr Raspe informed M. Magellan, that nickel was found mineralized with sulphurated iron and copper in a mine near Nellstone in Cornwall. The fine grained and scaly kinds are found in loose cobalt mines in the province of Helsingeland in Sweden, where they are of a lighter colour than in other countries, and have often been confounded with the liver-coloured marcasite.

4. Nickel mineralized with the acid of vitriol is of a beautiful green colour, and may be extracted from the nickel-ochre, or green efflorescences of *kupfer-nickel* already mentioned.

To the properties of nickel already mentioned, we may add that of its being constantly attracted by the magnet, and that not at all in proportion to the quantity of iron it contains; for the more it is purified from this metal, the more magnetical it becomes; and even acquires what iron does not, viz. the properties of a true loadstone.

NICOBAR ISLANDS, the name of several islands in Asia, lying at the entrance of the gulph of Bengal. The largest of these islands is about 40 miles long and 15 broad, and the inhabitants are said to be a harmless sort of people, ready to supply the ships that stop there with provisions. The south end of the great Nicobar is by Captain Ritchie placed in east longitude $94^{\circ} 23' 30''$; and we collect from Mr Rannell's Memoir, that it is within the 12th degree of north latitude.

Of these islands very little that can be depended upon is known in Europe. Of the northernmost, No 242.

which is called *Carnicobar*, we have indeed, in the second volume of the Asiatic Researches, some interesting information respecting both the produce and natural history of the country, and the manners of its inhabitants. The author of the memoir is Mr G. Hamilton, who, in his account of this island, says, "It is low, of a round figure, about 40 miles in circumference, and appears at a distance as if entirely covered with trees: however, there are several well-cleared and delightful spots upon it. The soil is a black kind of clay, and marshy. It produces in great abundance, and with little care, most of the tropical fruits, such as pine-apples, plantains, papayas, cocoa-nuts, and areca-nuts; also excellent yams, and a root called *cachu*. The only four-footed animals upon the island are, hogs, dogs, large rats, and an animal of the lizard kind, but large, called by the natives *tolongui*; these frequently carry off fowls and chickens. The only kind of poultry are hens, and those not in great plenty. There are abundance of snakes of many different kinds, and the inhabitants frequently die of their bites. The timber upon the island is of many sorts, in great plenty, and some of it remarkably large, affording excellent materials for building or repairing ships.

"The natives are low in stature but very well made, and surprisingly active and strong; they are copper-coloured, and their features have a cast of the Malay; quite the reverse of elegant. The women in particular are extremely ugly. The men cut their hair short, and the women have their heads shaved quite bare, and wear no covering but a short petticoat, made of a sort of rush or dry grass, which reaches half way down the thigh. This grass is not interwoven, but hangs round the person something like the thatching of a house. Such of them as have received presents of cloth-petticoats from the ships, commonly tie them round immediately under the arms. The men wear nothing but a narrow strip of cloth about the middle, in which they wrap up their privities so tight that there hardly is any appearance of them. The ears of both sexes are pierced when young; and by squeezing into the holes large plugs of wood, or hanging heavy weights of shells, they contrive to render them wide, and disagreeable to look at. They are naturally disposed to be good humoured and gay, and are very fond of sitting at table with Europeans, where they eat every thing that is set before them; and they eat most enormously. They do not care much for wine, but will drink bumpers of *arak* as long as they can see. A great part of their time is spent in feasting and dancing. When a feast is held at any village, every one that chooses goes uninvited, for they are utter strangers to ceremony. At those feasts they eat immense quantities of pork, which is their favourite food. Their hogs are remarkably fat, being fed upon the cocoa-nut kernel and sea-water; indeed all their domestic animals, fowls, dogs, &c. are fed upon the same. They have likewise plenty of small sea-fish, which they strike very dexterously with lances, wading into the sea about knee deep. They are sure of killing a very small fish at 10 or 12 yards distance. They eat the pork almost raw, giving it only a hasty grill over a quick fire. They roast a fowl, by running a piece of wood thro' it,

Nicobar. it, by way of spit, and holding it over a brisk fire until the feathers are burnt off, when it is ready for eating, in their taste. They never drink water; only cocoa-nut milk and a liquor called *foura*, which oozes from the cocoa-nut tree after cutting off the young sprouts or flowers. This they suffer to ferment before it is used, and then it is intoxicating; to which quality they add much by their method of drinking it, by sucking it slowly through a small straw. After eating, the young men and women, who are fancifully dressed with leaves, go to dancing, and the old people surround them smoking tobacco and drinking *foura*. The dancers, while performing, sing some of their tunes, which are far from wanting harmony, and to which they keep exact time. Of musical instruments they have only one kind, and that the simplest. It is a hollow bamboo about 2½ feet long and three inches in diameter, along the outside of which there is stretched from end to end a single string made of the threads of a split cane, and the place under the string is hollowed a little to prevent it from touching. This instrument is played upon in the same manner as a guitar. It is capable of producing but few notes; the performer however makes it speak harmoniously, and generally accompanies it with the voice.

"Their houses are generally built upon the beach in villages of 15 or 20 houses each; and each house contains a family of 20 persons and upwards. These habitations are raised upon wooden pillars about 10 feet from the ground; they are round, and, having no windows, are like bee-hives, covered with thatch. The entry is through a trap-door below, where the family mount by a ladder, which is drawn up at night. This manner of building is intended to secure the houses from being infested with snakes and rats; and for that purpose the pillars are bound round with a smooth kind of leaf, which prevents animals from being able to mount; besides which, each pillar has a broad round flat piece of wood near the top of it, the projecting of which effectually prevents the further progress of such vermin as may have passed the leaf. The flooring is made with thin strips of bamboos, laid at such distances from one another as to leave free admission for light and air; and the inside is neatly finished and decorated with fishing lances, nets, &c.

"The art of making cloth of any kind is quite unknown to the inhabitants of this island; what they have is got from the ships that come to trade in cocoa nuts.

"They purchase a much larger quantity of cloth than is consumed upon their own island. This is intended for the Choury market. Choury is a small island to the southward of theirs, to which a large fleet of their boats sails every year about the month of November, to exchange cloth for canoes; for they cannot make these themselves. This voyage they perform by the help of the sun and stars, for they know nothing of the compass.

"In their disposition there are two remarkable qualities. One is their entire neglect of compliment and ceremony; and the other, their aversion to dishonesty. A Carnicobarian travelling to a distant village, upon business or amusement, passes through many towns in

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his way without speaking to any one; if he is hungry or tired, he goes into the nearest house, and helps himself to what he wants, and sits till he is rested, without taking the smallest notice of any of the family unless he has business or news to communicate. Theft or robbery is so very rare amongst them, that a man going out of his house never takes away his ladder or shuts his door, but leaves it open for any body to enter that pleases, without the least apprehension of having any thing stolen from him.

"Their intercourse with strangers is so frequent, that they have acquired in general the barbarous Portuguese so common over India; their own language has a sound quite different from most others, their words being pronounced with a kind of stop, or catch in the throat, at every syllable.

"They have no notion of a God, but they believe firmly in the devil, and worship him from fear. In every village there is a high pole erected with long strings of ground-rattans hanging from it, which, it is said, has the virtue to keep him at a distance. When they see any signs of an approaching storm, they imagine that the devil intends them a visit, upon which many superstitious ceremonies are performed. The people of every village march round their own boundaries, and fix up at different distances small sticks split at the top, into which split they put a piece of cocoa-nut, a wisp of tobacco, and the leaf of a certain plant: whether this is meant as a peace offering to the devil, or a scarecrow to frighten him away, does not appear.

"When a man dies, all his live stock, cloth, hatchets, fishing-lances, and in short every moveable thing he possessed, is buried with him, and his death is mourned by the whole village. In one view this is an excellent custom, seeing it prevents all disputes about the property of the deceased amongst his relations. His wife must conform to custom by having a joint cut off from one of her fingers; and if she refuses this, she must submit to have a deep notch cut in one of the pillars of her house.

"I was once present at the funeral of an old woman. When we went into the house which had belonged to the deceased, we found it full of her female relations; some of them were employed in wrapping up the corpse in leaves and cloth, and others tearing to pieces all the cloth which had belonged to her. In another house hard by, the men of the village, with a great many others from the neighbouring towns, were sitting drinking *foura* and smoking tobacco. In the mean time two stout young fellows were busy digging a grave in the sand near the house. When the women had done with the corpse, they set up a most hideous howl, upon which the people began to assemble round the grave, and four men went up into the house to bring down the body; in doing this they were much interrupted by a young man, son to the deceased, who endeavoured with all his might to prevent them, but finding it in vain, he clung round the body, and was carried to the grave along with it: there, after a violent struggle, he was turned away and conducted back to the house. The corpse being now put into the grave, and the lashings which bound the legs and arms cut, all the live-stock which had been the property of the deceased, consisting of

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about

Nicobar.

Nicobar, about half a dozen hogs, and as many fowls, was killed, and flung in above it; a man then approached with a bunch of leaves stuck upon the end of a pole, which he swept two or three times gently along the corpse, and then the grave was filled up. During the ceremony, the women continued to make the most horrible vocal concert imaginable: the men said nothing. A few days afterwards, a kind of monument was erected over the grave, with a pole upon it, to which long strips of cloth of different colours were hung.

"Polygamy is not known among them; and their punishment of adultery is not less severe than effectual. They cut, from the man's offending member, a piece of the foreskin proportioned to the frequent commission or enormity of the crime.

"There seems to subsist among them a perfect equality. A few persons, from their age, have a little more respect paid to them; but there is no appearance of authority one over another. Their society seems bound rather by mutual obligations continually conferred and received; the simplest and best of all ties."

It is our wish to take all opportunities of laying before our readers every authentic fact which can throw light upon the philosophy of the human mind. In this narrative of Mr Hamilton's respecting the natives of Carnicobar, there is however one circumstance at which we stumble. It is known to the learned, that the philosophers of Greece and Rome, as well as the magi of Persia, admitted two self-existent beings, a good and an evil (see POLYTHEISM); but we never before read of any people who had no notion of a God, and yet firmly believed in the devil. We could give instances of men worshipping the evil principle from fear, and neglecting the worship of the benevolent principle, from a persuasion that he would do them all the good in his power without being bribed by sacrifices and oblations; but this is the only instance of which we have ever heard, of a people, under the influence of religion, who had *no notion of a God!* As good is at least as apparent in the world as evil, it appears to us so very unnatural to admit an *evil* and deny a *good* principle, that we cannot help thinking that Mr Hamilton, from his ignorance of the language of Carnicobar, (which he acknowledges to be different from most others), has not a perfect acquaintance with the religious creed of the natives; and that they believe in a good as well as in an evil principle, though they worship only the latter, from a persuasion, that to adore the former could be of no advantage either to him or to themselves.

NICODEMUS, a disciple of Jesus Christ, a Jew by nation, and by sect a Pharisee (John iii. i. &c.) The scripture calls him a ruler of the Jews, and our Saviour gives him the name of a master of Israel. When our Saviour began to manifest himself by his miracles at Jerusalem, at the first passover that he celebrated there after his baptism, Nicodemus made no doubt but that he was the Messiah, and came to him by night, that he might learn of him the way of salvation. Jesus told him, that no one could see the kingdom of heaven except he should be born again. Nicodemus taking this in the literal sense, made answer, "How can a man that is old be born again? Can

he enter a second time into his mother's womb?" To which Jesus replied, "If a man be not born of water and of the spirit, he cannot enter into the kingdom of God. That which is born of the flesh is flesh, and that which is born of the spirit is spirit." Nicodemus asks him, "How can these things be?" Jesus answered, "Are you a master of Israel, and are you ignorant of these things? We tell you what we know, and you receive not our testimony. If you believe not common things, and which may be called earthly, how will you believe me if I speak to you of heavenly things? Nobody has ascended into heaven but the son of God, who came down from thence. And just as Moses lifted up the brazen serpent in the wilderness, so must the Son of Man be lifted up on high. For God so loved the world that he has given his only son, so that no man who believes in him shall perish, but shall have eternal life."

After this conversation Nicodemus became a disciple of Jesus Christ; and there is no doubt to be made, but he came to hear him as often as our Saviour came to Jerusalem. It happened on a time, that the priests and Pharisees had sent officers to seize Jesus (John vii. 45, &c.), who returning to them, made their report, that never man spoke as he did; to which the Pharisees replied, "Are you also of his disciples? Is there any one of the elders or Pharisees that have believed in him?" Then Nicodemus thought himself obliged to make answer, saying, "Does the law permit us to condemn any one before he is heard?" To which they replied, "Are you also a Gallilean? Read the scriptures, and you will find that never any prophet came out of Gallilee." After this the council was dismissed. At last Nicodemus declared himself openly a disciple of Jesus Christ (*id.* xix. 39. 40.), when he came with Joseph of Arimathea to pay the last duties to the body of Christ, which they took down from the cross, embalmed, and laid in a sepulchre.

We are told, that Nicodemus received baptism from the disciples of Christ; but it is not mentioned whether before or after the passion of our Lord. It is added, that the Jews being informed of this, deposed him from his dignity of senator, excommunicated him, and drove him from Jerusalem: but that Gamaliel, who was his cousin-german, took him to his country house, and maintained him there till his death, when he had him buried honourably near St Stephen. There is still extant an apocryphal gospel under the name of Nicodemus, which in some manuscripts bears the title of the *Acts of Pilate*.

NICOLAITANS, in church-history, Christian heretics who assumed this name from Nicholas of Antioch; who, being a Gentile by birth, first embraced Judaism and then Christianity; when his zeal and devotion recommended him to the church of Jerusalem, by whom he was chosen one of the first deacons. Many of the primitive writers believe that Nicholas was rather the occasion than the author of the infamous practices of those who assumed his name, who were expressly condemned by the Spirit of God himself, Rev. ii. 6. And indeed their opinions and actions were highly extravagant and criminal. They allowed a community of wives, and made no distinction between ordinary meats and those offered to idols. According to Eusebius, they subsisted but a short time;

Nicolas time; but Tertullian says, that they only changed their name, and that their heresies passed into the sect of the Cainites.

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Nicomedes.

NICOLAS (St), an island of the Atlantic Ocean, and one of the most considerable of those of Cape Verde, lying between Santa Lucia and St Jago. It is of a triangular figure, and about 75 miles in length. The land is stony, mountainous, and barren; but there are a great many goats in a valley inhabited by the Portuguese. W. Long. 33. 35. N. Lat. 17. 0.

NICOLE (Peter), one of the finest writers in Europe, was born at Chartres in 1625, of a conspicuous family. He adhered to the Jansenists; and joined in the composition of several works with Mr Arnauld, whose faithful companion he was during the 10 or 12 years of his retirement. He gave a Latin translation of Pascal's *Provinciales*, and added a commentary to them. One of his finest works is his *Essais de Morale*. He wrote very subtly against the Protestants. His treatise on the unity of the church is esteemed a masterly piece. He died at Paris in 1695, a few days after the publication of his treatise concerning the Quietists. He was well skilled in polite literature. To him is ascribed a collection of Latin epigrams, and of Greek, Spanish, and Italian sentences, which has borne several impressions, and has a learned preface to it.

NICOLO (St), the most considerable, strongest, and best peopled of the isles of Tremeti in the gulf of Venice, to the east of St Domino, and to the south of Capparata. It has a harbour defended by several towers; and a fortress, in which is an abbey, with a very handsome church. E. Long. 15. 37. N. Lat. 42. 7.

NICOMEDES, the name of several kings of the ancient Bithynia. See BITHYNIA.

NICOMEDES I. had no sooner taken possession of his father's throne, before Christ 270, than, according to the custom which has in all ages been too prevalent among the despots of the east, he caused two of his brothers to be put to death. The youngest, Zibœas, having saved himself by timely flight, seized on the coast of Bithynia, which was then known by the names of *Thracia*, *Thynicia*, and *Thracia Asiatica*, and there maintained a long war with his brother. Nicomedes being informed that Antiochus Soter, king of Syria, was making great preparations to attack him at the same time, called in the Gauls to his assistance; and on this occasion that people first passed into Asia. — Nicomedes having with their assistance repulsed Antiochus, overcome his brother, and acquired the possession of all his father's dominions, bestowed upon them that part of Asia Minor which from them was called *Gallo-Græcia*, and Gallatia. Having now no enemies to contend with, he applied himself to the enlarging and adorning of the city of Astacus, which he called after his own name *Nicomedia*. He had two wives, and by one of them he was persuaded to leave his kingdom to her son, in preference to his elder brothers; but when or how he died is not certainly known.

NICOMEDES II. the grandson of the former, began his reign like him, by sacrificing his brothers to his jealousy, after having waded to the throne in the blood

of Prusias his father. He assumed the name of *Euphanes*, or "the Illustrious," though he performed nothing worthy of this title, or even of notice, during the whole time of his long reign. He was succeeded by his son. —

NICOMEDES III. surnamed by Antiphrasis, *Philopater*, because he had murdered his father to get possession of his crown. This monarch having entered into alliance with Mithridates the Great king of Pontus, invaded Paphlagonia; and having seized on that country, he attempted likewise to make himself master of Cappadocia. This country, however, was at that time subject to his powerful ally; who thereupon marching into Bithynia at the head of an army, drove Nicomedes from the throne, and raised his brother Socrates to it in his room. The dethroned prince had recourse to the Romans, who expelled the usurper, and restored him to his hereditary dominions. For this favour they pressed him, and at length prevailed upon him, contrary to his own inclination, and the opinion of his friends, to make inroads into the territories of Mithridates, with whom Rome wanted a subject of dispute. The king of Pontus bore for some time the devastations committed by Nicomedes with great patience, that he might not seem to be the aggressor; but at last he routed his army on the banks of the Amnion, drove him a second time from his dominions, and obliged him to seek for shelter in Paphlagonia, where he led a private life till the time of Sylla, who replaced him on the throne. He was succeeded by his son. —

NICOMEDES IV. who performed nothing which the many writers who flourished in his time have thought worth transmitting to posterity. As he died without issue male, he left his kingdom by his last will to the Romans, who reduced it to the form of a province. Sallust, disagreeing with the ancients, tells us, that Nicomedes left a son named *Musa* or *Myfa*; and introduces Mithridates as complaining of the Romans to Arsaces king of Parthia, for seizing on the kingdom of Bithynia, and excluding the son of a prince who had on all occasions shown himself a steady friend to their republic. But this Musa was the daughter and not the son of Nicomedes, as we are told in express terms by Suetonius, Velleius Paterculus, and Appian. All we know of her is, that upon the death of her father she claimed the kingdom of Bithynia for her son, as the next male heir to the crown; but without success, no motives of justice being of such weight with the ambitious Romans as to make them part with a kingdom.

NICOMEDIA (anc. geog.), metropolis of Bithynia, built by Nicomedes the grandfather of Prusias. Situated on a point of the Sinus Astacenus, (Pliny); surnamed the *Beautiful*, (Athenæus): the largest city of Bithynia, (Pausanias), who says it was formerly called *Astacus*; though Pliny distinguishes Astacum and Nicomedia as different cities. Nicomedia was very famous, not only under its own kings, but under the Romans: it was the royal residence of Dioclesian, and of Constantine while Constantinople was building, if we may credit Nicephorus. It is still called *Nicomedia*, at the bottom of a bay of the Propontis in the Hither Asia. E. Long. 30. 0. N. Lat. 41. 20.

Nicomedus, It is a place of consequence; carries on a trade in silk, cotton, glass, and earthen-ware, and is the see of a Greek archbishop.

Nicon.

NICOMEDUS, a geometrician, famous on account of the invention of the curve called *conchoid*, which is equally useful in resolving the two problems of doubling the cube and trisecting the angle. It appears that he lived soon after Eratosthenes, for he rallied that philosopher on the mechanism of his mesolabe. Geminus, who lived in the second century before Jesus Christ, has written on the *conchoid*, though Nicomedus was always esteemed the inventor of it. Those who place him four or five centuries after Jesus Christ must be ignorant of these facts, by which we are enabled to ascertain pretty nearly the time in which he lived.

NICON, a native of Russia, was born in 1613, in a village of the government of Nishnei Novogorod, of such obscure parents, that their names and station are not transmitted to posterity. He received at the baptismal font the name of *Nikita*, which afterwards, when he became monk, he changed to *Nicon*, the appellation by which he is more generally known. He was educated in the convent of St Macarius, under the care of a monk. From the course of his studies, which were almost solely directed to the Holy Scriptures, and the exhortations of his preceptor, he imbibed at a very early period the strongest attachment to a monastic life; and was only prevented from following the bent of his mind by the persuasions and authority of his father. In conformity, however, to the wishes of his family, though contrary to his own inclination, he entered into matrimony; and, as that state precluded him from being admitted into a convent, he was ordained a secular priest. With his wife he continued 15 years, partly in the country and partly at Moscow, officiating as a parish-priest. The loss of three children, however, gave him a total disgust to the world; in consequence of which, his wife was persuaded to take the veil, and he became a monk; his retreat was in an island of the White Sea, and a kind of ecclesiastical establishment was formed, as remarkable for the austerities of its rules as the situation was for its solitude. There were about 12 monks, but they all lived in different cells. Such a system, combined with the most gloomy ideas, occasioned so much cloistered pride as tarnished his character, when he was afterwards called up to fulfil the duties of a public and exalted station. Our limits do not permit us to be minute in our account of his life; we must therefore be contented with barely reciting general facts. Within less than the space of five years, Nicon was successively created archimandrite, or abbot of the Novospatskoi convent, archbishop of Novogorod, and patriarch of Russia. That he was worthy of these rapid promotions, few will doubt who are acquainted with his character; for he was possessed of very extraordinary qualities, such as even his enemies allow and admire. His courage was undaunted, his morals irreproachable, his charity extensive and exalted, his learning deep and comprehensive, and his eloquence commanding.—When archbishop, he obtained the respect of the inhabitants by his unwearied assiduity in the discharge of his trust; and conciliated their affections by acts of unbounded charity: Nor was he less conspicuous in

the discharge of the office of patriarch, to which dignity he was appointed in 1652, in the 39th year of his age.

Nor was he only distinguished in his own profession, for he shone even as a statesman. At length, however, he fell a victim to popular discontents; which misfortune, though he was far from deserving it, was certainly the effect of imprudence. He abdicated the office of patriarch, which would otherwise have been taken from him, in July 1658, and bore his reverse of fortune with heroic magnanimity: he returned to a cell, and commenced his former austerities. His innocence, however, could not protect him from further malice: his enemies obtained him to be formally deposed in 1666. This degradation was followed by imprisonment, which was for some time very rigorous, because he, conscious of his own innocence, refused to accept pardon for crimes of which he was not guilty. In 1676, however, he was removed to the convent of St Cyril, and enjoyed perfect liberty.

Nicon survived his deposition 15 years. In 1681, he requested and obtained permission to return to the convent of Jerusalem, that he might end his days in that favourite spot; but he expired upon the road near Yaroslaf, in the 66th year of his age. His remains were transported to that convent, and buried with all the ceremonies used at the interment of patriarchs.

NICOPOLI, a town of Turkey in Europe, and in Bulgaria, famous for being the place where the first battle was fought between the Turks and Christians in 1396; and where the latter were defeated with the loss of 20,000 men. E. Long. 25. 33. N. Lat. 43. 46.

NICOSIA, the capital of the island of Cyprus, where a Turkish bashaw resides. It is delightfully situated between the mountains of Olympus and a chain of others; and was formerly well fortified by the Venetians; but the works are now in ruins. It is about 31 miles in circumference; and there are plantations of olives, almonds, lemons, oranges, mulberries, and cypress-trees, interspersed among the houses, which give the town a delightful appearance. The church of Sancta Sophia is an old Gothic structure, which the Turks have turned into a mosque, and destroyed the ornaments. It is 100 miles west of Tripoli, and 160 south-west of Aleppo. E. Long. 34. 45. N. Lat. 34. 54.

NICOT (John), lord of Villemain, and master of requests of the French king's household, was born at Nîmes, and was sent ambassador to Portugal in 1559; whence he brought the plant which, from his name, was called *Nicotiana*, but is now more generally known by the name of *Tobacco*. He died at Paris in 1603. He wrote a French and Latin dictionary in folio; a treatise on navigation; and other works.

NICOTIANA, **TOBACCO**, in botany: A genus of the monogynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 28th order, *Lurida*. The corolla is funnel-shaped, with a plaited limb; the stamina inclined; the capsule bivalved and bilocular. There are seven species, of which the most remarkable is the *tabacum*, or common tobacco-plant. This was first discovered in America by the Spaniards about the year 1560, and

Nicon
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Nicotiana.

Nicotiana. by them imported into Europe. It had been used by the inhabitants of America long before; and was called by those of the islands *yoli*, and *patun* by the inhabitants of the continent. It was sent into Spain from Tabaco, a province of Yucatan, where it was first discovered, and from whence it takes its common name. Sir Walter Raleigh is generally said to have been the first that introduced it into England about the year 1585, and who taught his countrymen how to smoke it. Dr Cotton Mather, however, (in his *Christian Philosopher*) says, that in the above year one Mr Lane carried over some of it from Virginia, which was the first that had ever been seen in Europe. Tobacco is commonly used among the oriental nations, though it is uncertain by whom it was introduced among them. Considerable quantities of it are cultivated in the Levant, on the coasts of Greece and the Archipelago, in Italy, and in the island of Malta.

There are two varieties of that species of *Nicotiana* which is cultivated for common use, and which are distinguished by the names of *Oronokoe*, and *sweet-scented tobacco*. They differ from each other only in the figure of their leaves; those of the former being longer and narrower than the latter. They are tall herbaceous plants, growing erect with fine foliage, and rising with a strong stem from six to nine feet high. The stalk, near the root, is upward of an inch diameter, and surrounded with a kind of hairy or velvet clammy substance, of a yellowish-green colour. The leaves are rather of a deeper green, and grow alternately at the distance of two or three inches from each other. They are oblong, of a spear-shaped oval, and simple; the largest about 20 inches long, but decreasing in size as they ascend, till they come to be only 10 inches long, and about half as broad. The face of the leaves is much corrugated, like those of spinach when full ripe. Before they come to maturity, when they are about five or six inches long, the leaves are generally of a full green, and rather smooth; but as they increase in size, they become rougher, and acquire a yellowish cast. The stem and branches are terminated by large bunches of flowers collected into clusters, of a delicate red; the edges, when full-blown, inclining to a pale purple. They continue in succession till the end of the summer; when they are succeeded by seeds of a brown colour, and kidney-shaped. These are very small, each capsule containing about 1000; and the whole produce of a single plant is reckoned at about 350,000. The seeds ripen in the month of September.

Mr Carver informs us, that the *Oronokoe*, or, as it is called, the *long Virginian tobacco*, is the kind best suited for bearing the rigour of a northern climate, the strength as well as the scent of the leaves being greater than that of the other. The *sweet-scented* sort flourishes most in a sandy soil, and in a warm climate, where it greatly exceeds the former in the celerity of its growth; and is likewise, as its name intimates, much more mild and pleasant.

Culture. Tobacco thrives best in a warm, kindly, rich soil, that is not subject to be over-run by weeds. In Virginia, the soil in which it thrives best, is warm, light, and inclining to be sandy; and therefore, if the plant is to be cultivated in Britain, it ought to be planted in a soil as nearly of the same kind as possible. Other kinds of soil might probably be brought to suit it, by

a mixture of proper manure; but we must remember, that whatever manure is made use of, must be thoroughly incorporated with the soil. The best situation for a tobacco plantation is the southern declivity of a hill rather gradual than abrupt, or a spot that is sheltered from the north winds: but at the same time it is necessary that the plants enjoy a free air; for without that they will not prosper.

As tobacco is an annual plant, those who intend to cultivate it ought to be as careful as possible in the choice of the seeds; in which, however, with all their care, they may be sometimes deceived. The seeds are to be sown about the middle of April, or rather sooner in a forward season, in a bed prepared for this purpose of such soil as has been already described, mixed with some warm rich manure. In a cold spring, hot-beds are most eligible for this purpose, and gardeners imagine that they are always necessary: but Mr Carver tells us, that he is convinced, when the weather is not very severe, the tobacco-seeds may be raised without doors; and for this purpose gives us the following directions.

“Having sown the seed in the manner above directed, on the least apprehension of a frost after the plants appear, it will be necessary to spread mats over the beds, a little elevated from the ground by poles laid across, that they may not be crushed. These, however, must be removed in the morning soon after the sun appears, that they may receive as much benefit as possible from its warmth and from the air. In this manner proceed till the leaves have attained about two inches in length and one in breadth; which they will do in about a month after they are sown, or near the middle of May, when the frosts are usually at an end. One invariable rule for their being able to bear removal is, when the fourth leaf is sprouted, and the fifth just appears. Then take the opportunity of the first rains or gentle showers to transplant them into such a soil and situation as before described; which must be done in the following manner.—The land must be ploughed, or dug up with spades, and made as mellow and light as possible. When the plants are to be placed, raise with the hoe small hillocks at the distance of two feet or a little more from each other, taking care that no hard sods or lumps are in it; and then just indent the middle of each, without drilling holes, as for some other plants.

“When your ground is thus prepared, dig in a gentle manner from their native bed such plants as have attained the proper growth for transplanting above-mentioned; and drop, as you pass, one on every hillock. Insert a plant gently into each centre, pressing the soil around it gently with your fingers; and taking the greatest care, during the operation, that you do not break off any of the leaves, which are at this time exquisitely tender. If the weather proves dry after they are thus transplanted, they must be watered with soft water, in the same manner as is usually done to coleworts, or plants of a similar kind. But though you now seem to have a sufficient quantity of plants for the space you intend to cultivate, it is yet necessary that you continue to attend to your bed of seedlings, that you may have enough to supply any deficiencies which through accident may arise. From this time great care must be taken to keep the ground soft and free

*Treatise on
the Culture
of Tobacco.*

Nicotiana. free from weeds, by often stirring with your hoe the mould round the roots; and to prune off the dead leaves that sometimes are found near the bottom of the stalk.

"The difference of this climate from that in which I have been accustomed to observe the progress of this plant, will not permit me to direct with certainty the time which is most proper to take off the top of it, to prevent it from running to seed. This knowledge can only be acquired by experience. When it has risen to the height of more than two feet, it commonly begins to put forth the branches on which the flowers and seeds are produced; but as this expansion, if suffered to take place, would drain the nutriment from the leaves, which are the most valuable part, and thereby lessen their size and efficacy, it becomes needful at this stage to nip off the extremity of the stalk to prevent its growing higher. In some other climates, the top is commonly cut off when the plant has 15 leaves; but if the tobacco is intended to be a little stronger than usual, this is done when it has only 13; and sometimes, when it is designed to be remarkably powerful, 11 or 12 are only allowed to expand. On the contrary, if the planter is desirous of having his crop very mild, he suffers it to put forth 18 or 20: but in this calculation, the three or four lower leaves next the ground, which do not grow so large and fine as the others, are not to be reckoned.

"This operation, denominated *topping* the tobacco, is much better performed by the finger and thumb than with any instrument; because the grasp of the fingers closes the pores of the plant; whereas, when it is done by instruments, the juices are in some degree exhausted. Care must also be taken to nip off the sprouts that will be continually springing up at the junction of the leaves with the stalks. This is termed *succouring*, or *suckering*, the tobacco; and ought to be repeated as often as occasion requires.

"As it is impossible to ascertain the due time for topping the plant, so it is equally impossible, without experiment, to ascertain the time it will take to ripen in this country. The apparent signs of its maturity are these: The leaves, as they approach a state of ripeness, become more corrugated or rough; and when fully ripe, appear mottled with yellowish spots on the raised parts; whilst the cavities retain their usual green colour. They are at this time also thicker than they have before been; and are covered with a downy velvet, like that formerly mentioned, on the stalks. If heavy rains happen at this critical period, they will wash off this excrecent substance, and thereby damage the plants. In this case, if the frosty nights are not begun, it is proper to let them stand a few days longer; when, if the weather be moderate, they will recover this substance again. But if a frost unexpectedly happens during the night, they must be carefully examined in the morning, before the sun has any influence upon them; and those which are found to be covered with frosty particles, whether thoroughly ripe or not, must be cut up; for though they may not all appear to be arrived at a state of maturity, yet they cannot be far from it, and will differ but little in goodness from those that are perfectly so."

Tobacco is subject to be destroyed by a worm; and without proper care to exterminate this enemy, a

whole field of plants may soon be lost. This animal *Nicotiana*. is of the horned species, and appears to be peculiar to the tobacco-plant; so that in many parts of America it is distinguished by the name of the *tobacco-worm*. In what manner it is first produced, or how propagated, is unknown: but it is not discernible till the plants have attained about half their height; and then appears to be nearly as large as a gnat. Soon after this it lengthens into a worm; and by degrees increases in magnitude to the bigness of a man's finger. In shape it is regular from its head to its tail, without any diminution at either extremity. It is indented or ribbed round at equal distances, nearly a quarter of an inch from each other; and having at every one of these divisions a pair of feet or claws, by which it fastens itself to the plant. Its mouth, like that of the caterpillar, is placed under the fore-part of the head. On the top of the head, between the eyes, grows a horn about half an inch long, and greatly resembling a thorn; the extreme part of which is of a brown colour, a firm texture, and the extremity sharp-pointed. It is easily crushed; being only, to appearance, a collection of green juice inclosed in a membranous covering, without the internal parts of an animated being. The colour of its skin is in general green, interspersed with several spots of a yellowish white; and the whole covered with a short hair scarcely to be discerned. These worms are found the most predominant during the latter end of July and the beginning of August; at which time the plants must be particularly attended to, and every leaf carefully searched. As soon as a wound is discovered, and it will not be long before it is perceptible, care must be taken to destroy the cause of it, which will be found near it, and from its unsubstantial texture may easily be crushed: but the best method is to pull it away by the horn, and then crush it.

When the tobacco is fit for being gathered, as will appear from an attention to the foregoing directions, on the first morning that promises a fair day, before the sun is risen, take an ax or a long knife, and holding the stalk near the top with one hand, sever it from its root with the other, as low as possible. Lay it gently on the ground, taking care not to break off the leaves, and there let it remain exposed to the rays of the sun throughout the day, or until the leaves, according to the American expression, are entirely *wilted*; that is, till they become limber, and will bend any way without breaking. But if the weather should prove rainy without any intervals of sunshine, and the plants appear to be fully ripe, they must be housed immediately. This must be done, however, with great care, that the leaves, which are in this state very brittle, may not be broken. They are next to be placed under proper shelter, either in a barn or covered hovel, where they cannot be affected by rain or too much air, thinly scattered on the floor; and if the sun does not appear for several days, they must be left to wilt in that manner; but in this case the quantity of the tobacco will not be quite so good.

When the leaves have acquired the above mentioned flexibility, the plants must be laid in heaps, or rather in one heap if the quantity is not too great, and in about 24 hours they will be found to sweat. But during this time, when they have lain for a little while, and begin to ferment, it will be necessary to turn them;

Nicotiana them; bringing those which are in the middle to the surface, and placing those which are at the surface in the middle. The longer they lie in this situation, the darker-coloured is the tobacco; and this is termed *sweating* the tobacco. After they have lain in this manner for three or four days, for a longer continuance might make the plants turn mouldy, they may be fastened together in pairs with cords or wooden pegs, near the bottom of the stalk, and hung across a pole, with the leaves suspended in the same covered place, a proper interval being left between each pair. In about a month the leaves will be thoroughly dried, and of a proper temperature to be taken down. This state may be ascertained by their appearing of the same colour with those imported from America. But this can be done only in wet weather.—The tobacco is exceedingly apt to attract the humidity of the atmosphere, which gives it a pliability that is absolutely necessary for its preservation; for if the plants are removed in a very dry season, the external parts of the leaves will crumble into dust, and a considerable waste will ensue.

Cure. As soon as the plants are taken down, they must again be laid in a heap, and pressed with heavy logs of wood for about a week; but this climate may possibly require a longer time. While they remain in this state, it will be necessary to introduce your hand frequently into the heap, to discover whether the heat be not too intense; for in large quantities this will sometimes be the case, and considerable damage will be occasioned by it. When they are found to heat too much, that is, when the heat exceeds a moderate glowing warmth, part of the weight by which they are pressed must be taken away; and the cause being removed, the effect will cease. This is called the *second* or *last sweating*; and, when completed, which it generally will be about the time just mentioned, the leaves may be stripped from the stalks for use. Many omit this last sweating; but Mr Carver thinks that it takes away any remaining harshness, and renders the tobacco more mellow. The strength of the stalk also is diffused by it through the leaves, and the whole mass becomes equally meliorated.—When the leaves are stripped from the stalks, they are to be tied up in bunches or *hands*, and kept in a cellar or other damp place; though if not handled in dry weather, but only during a rainy season, it is of little consequence in what part of the house or barn they are laid up. At this period the tobacco is thoroughly cured, and as proper for manufacturing as that imported from the colonies.

Our author advises the tobacco-planter, in his first trials, not to be too avaricious, but to top his plants before they have gained their utmost height; leaving only about the middle quantity of leaves directed before, to give it a tolerable degree of strength. For though this, if excessive, might be abated during the cure by an increase of sweating, or be remedied the next season by suffering more leaves to grow, it can never be added; and, without a certain degree of strength, the tobacco

will always be tasteless and of little value. On the contrary, though it be ever so much weakened by sweating, and thereby rendered mild, yet it will never lose the aromatic flavour, which accompanied that strength, and which greatly adds to its value. A square yard of land, he tells us, will rear about 500 plants, and allow proper space for their nurture till they are fit for transplanting.

The following extract, which is copied from a manuscript of Dr Barham (A), for directing the raising, cultivating, and curing tobacco in Jamaica, is perhaps worthy of the attention of those who wish to be further acquainted with this subject.

“Let the ground or woodland wherein you intend planting tobacco be well burned, as the greater the quantity of wood ashes the better. The spot you intend raising your plants on must be well strewed with ashes, laid smooth and light: then blow the seed from the palm of your hand gently on the bed, and cover it over with palm or plantain leaves.

“When your plants are about four inches high, draw them and plant them out about three feet asunder; and when they become as high as your knee, cut or pluck off the top; and if there are more than 12 leaves on the plant, take off the overplus, and leave the rest entire.

“The plant should now be daily attended to, in order to destroy the caterpillars that are liable to infest it; as also to take off every sprout or sucker that puts out at the joints, in order to throw the whole vegetable nourishment into the large leaves.

“When the edges and points of the leaves begin to turn a little yellow, cut down the stalks about ten o'clock in the morning, taking the opportunity of a fine day, and be careful the dew is fully off the plant, and do not continue this work after two in the afternoon. As fast as it is cut let it be carried into your tobacco-house, which must be so close as to shut out all air, (on this much depends), and hung up on lines tied across, for the purpose of drying.

“When the stalks begin to turn brownish, take them off the lines, and put them in a large binn, and lay on them heavy weights for 12 days; then take them out, and strip off the leaves, and put them again into the binn, and let them be well pressed, and so as no air gains admission for a month. Take them out; tie them in bundles about 60 leaves in each, which are called *monocoes*, and are ready for sale. But observe to let them always be kept close till you have occasion to dispose of them.

“Let your curing-house be well built, and very close and warm: if a boarded building, it will not be amiss, in a wet situation, to cover the whole outside with thatch and plantain trash, to keep off the damps; for by this care you preserve the fine volatile oil in the leaves. Observe, no smoke is to be made use of or admitted into your curing-house.”

Use. Since the introduction of tobacco into Europe 1560, various medical properties have been ascribed to it at different times by Stahl and other German physicians;

(A) This gentleman was cotemporary with Sir Hans Sloan. He was a man of great probity, an able physician, and a skilful naturalist. He collected and arranged a number of the plants of Jamaica, which he presented to Dr Sloan, and made several communications to the Royal Society.

Nicotiana. cians; but the manner in which of late years it has been spoken of by the generality of writers on materia medica, has occasioned it to be almost wholly dismissed from modern practice, at least from internal use: but this circumstance has not deterred Dr Fowler, a physician of eminence in Staffordshire, from commencing an inquiry into its medicinal effects; and he has given the result of his experiments, which seem to be accurately and faithfully related.

That tobacco, under proper regulations, may be administered internally, not only as a safe but as an efficacious remedy, especially as a diuretic in cases of dropy and dysury, seems certain enough. This property, amongst the vast number that have been attributed to it, however, seems scarcely ever to have been hinted at.

The forms in which Dr Fowler ordered it were either in infusion, tincture, or pills.

Take of tobacco leaves dried an ounce; boiling water one pound: infuse them for an hour in a close vessel set in a warm place, and strain off about 14 ounces. Then add two ounces of rectified spirit of wine.

Take of dried tobacco leaves an ounce, of rectified spirits, Spanish white wine, or vinegar, one pint, to be infused for four days.

Take of dried tobacco leaves in powder 1 drachm, of the conserve of roses enough to make it in a mass; which is to be divided into 60 pills.

Of the infusion, or tincture, Dr Fowler gives from six to 100 drops twice a day in water, or in a cordial julip, or other proper vehicle, sufficient to produce the effect in adults; but in irritable habits he seldom exceeded 25 drops. To a patient of 10 years old he gave 50 drops; to a child of five years old 20 drops; but to patients under five years old he never ventured to prescribe it.

The first effects of the infusion is a transient heat in the stomach and throat, as if the patient had taken a dram. The next general effect in a moderate dose is diuretic, with or without a slight vertigo and giddiness, and frequently nausea. In painful cases, it proves anodyne, and in some cases occasions drowsiness and sleep; in others drowsiness, with a sense of heat and restlessness.

Dr Fowler gave this medicine in 115 cases: in 93 of which it proved diuretic; in 40 of these cases it occasioned purging; 79 of these patients complained of vertigo. In 52 of the number it excited nausea; in the two last cases he directs the medicine to be suspended, and the doses lessened. Dr Fowler tried it in 30 cases of dropy, viz. four of anasarca, or general dropy; two of ascites; and 12 of dropical swellings of the legs, were all cured. In ten other cases it afforded considerable relief; and in three cases only it was of no use. In ten instances of dysury, the infusion was anodyne and diuretic, thereby abating pain, relaxing the urinary passages, and promoting urine.—In dysuries from gravel, it facilitates the expulsion of calcareous or gritty matter.

Dr Fowler speaks of the use of tobacco in injections; an ounce of the infusion in a pint of water-gruel at a time, and repeated in cases of obstinate constipation, as the case may require. In the *drybelly ach*, in the West Indies, injections of the

N^o 242.

smoke of tobacco have long been employed with the happiest effects. *Nicotiana, Nicotating.*

After all, the internal use of tobacco should be very limited, and can only be safe in the hands of a skilful and attentive practitioner. Tobacco is sometimes used externally in unguents for destroying cutaneous insects, cleansing old ulcers, &c. Beaten into a mass with vinegar or brandy, it has sometimes proved serviceable for removing hard tumours of the hypochondres: an account is given in the Edinburgh Essays of two cases of this kind cured by it. The most common uses of this plant, however, are either as a sternutatory when taken by way of snuff, as a masticatory by chewing it in the mouth, or as effluvia by smoking it; and when taken in moderation, it is not an unhealthful amusement. Before pipes were invented, it was usually smoked in segars, and they are still in use among some of the southern nations. The method of preparing these is at once simple and expeditious. A leaf of tobacco being formed into a small twisted roll, somewhat larger than the stem of a pipe, and about eight inches long, the smoke is conveyed through the winding folds which prevent it from expanding, as through a tube; so that one end of it being lighted, and the other applied to the mouth, it is in this form used without much inconvenience. But, in process of time, pipes being invented, they were found more commodious vehicles for the smoke, and are now in general use.

Among all the productions of foreign climes introduced into these kingdoms, scarce any has been held in higher estimation by persons of every rank than tobacco. In the countries of which it is a native, it is considered by the Indians as the most valuable offering that can be made to the beings they worship. They use it in all their civil and religious ceremonies. When once the spiral wreaths of its smoke ascend from the feathered pipe of peace, the compact that has been just made is considered as sacred and inviolable. Likewise, when they address their great Father, or his guardian spirits, residing, as they believe, in every extraordinary production of nature, they make liberal offerings to them of this valuable plant, not doubting but that they are thus secured of protection.

Tobacco is made up into rolls by the inhabitants of the interior parts of America, by means of a machine called a *tobacco-wheel*. With this machine they spin the leaves after they are cured, into a twist of any size they think fit; and having folded it into rolls of about 20 pounds each, they lay it by for use. In this state it will keep for several years, and be continually improving, as it always grows milder. The Illinois usually form it into carrots; which is done by laying a number of leaves, when cured, on each other after the ribs have been taken out, and rolling them round with packthread, till they become cemented together. These rolls commonly measure about 18 or 20 inches in length, and nine round in the middle part.

Tobacco forms a very considerable article in commerce; for an account of which see the articles GLASGOW and VIRGINIA.

NICTITATING MEMBRANE, a thin membrane chiefly found in the bird and fish kind, which covers the eyes of these animals, sheltering them from the dust or too much light; yet is so thin and pellucid, that they can see pretty well through it.

NIDDUI,

Niddul
Nieder.

NIDDUL, in the Jewish customs, is used to signify "separated or excommunicated." This, according to some, was to be understood of the lesser sort of excommunication in use among the Hebrews. He that had incurred it was to withdraw himself from his relations, at least to the distance of four cubits: it commonly continued a month. If it was not taken off in that time, it might be prolonged for 60 or even 90 days: but if, within this term, the excommunicated person did not give satisfaction, he fell into the *cherem*, which was a second sort of excommunication; and thence into the third sort, called *shammata* or *shematta*, the most terrible of all. But Selden has proved that there were only two kinds of excommunication, *viz.* the greater and less; and that these three terms were used indifferently.

NIDUS, among naturalists, signifies a nest or proper repository for the eggs of birds, insects, &c. where the young of these animals are hatched and nursed.

NIDIFICATION, a term generally applied to the formation of a bird's nest, and its hatching or bringing forth its young. See **ORNITHOLOGY**.

NIECE, a brother's or sister's daughter, which in the civil law is reckoned the third degree of consanguinity.

NIEMEN, a large river of Poland, which rises in Lithuania, where it passes by Bielica, Grodno, and Konno: it afterwards runs through part of Samogitia and Ducal Prussia, where it falls into the lake called the *Curisch-baff*, by several mouths, of which the most northern is called the *Rufs*, being the name of a town it passes by.

NIENBURG, a rich and strong town of Germany, in the duchy of Brunswick-Lunenbourg, with a strong castle. It carries on a considerable trade in corn and wool, and is seated in a fertile soil on the river Weser. E. Long. 9. 26. N. Lat. 52. 44.

NIEPER, a large river of Europe, and one of the most considerable of the North, formerly called the *Boristhenes*. Its source is in the middle of Muscovy, running west by Smolensko, as far as Orsa; and then turns south, passing by Mohilow, Bohaczo, Kiow, Czyrkassy, the fortresses of Kudak, Dessau, and Oczakow, falling into the Black Sea; as also in its course it divides Little Tartary from Budziac Tartary.

NIESS, a mountain in the environs of Berne in Switzerland. It is the last mountain in a high calcareous chain of hills, of which the Stockhorn, the Neunerén, and the Ganterish, have been illustrated by the botanical labours of the celebrated Haller. Niefs stands on the borders of the lake Thun, and separates the valley of Frutigen from that of Simme. It is very interesting to the curious traveller, on account of the fine view from its top; and to naturalists, because it joins the Alps. Towards its foot, beds of slate have been discovered; it is of calcareous stone higher up; and near its top is found a species of pudding-stone, filled with small fragments of broken petrifications.

NIESTER, a large river of Poland, which has its source in the Lake Neister, in the palatinate of Lemburg, where it passes by Halicz. Then it separates Podolia and Oczakow Tartary from Moldavia and Budziac Tartary; and falls into the Black Sea at

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Belgorod, between the mouths of the Nieper and the Danube.

NIEUHOFF (John de), a Dutch author, was born about the beginning of the last century. We are indebted to him for a valuable and curious account, written in Dutch, of his embassy from the Dutch East India Company to the emperor of China. Jean le Carpentier published an excellent translation of it into French, in folio, Leyden, 1665. This edition is rare, and the book is in great request.

NIEUWENTYF (Bernard), an able philosopher and learned mathematician, was born at Westgraafdyk, in the year 1654, and became counsellor and burgo-master of the town of Purmerend, where he was esteemed for his integrity and learning, and died in 1718. He wrote, in Dutch, 1. An excellent treatise, intitled, *The Existence of God demonstrated by the Works of Nature*. 2. *A Refutation of Spinoza*. 3. *Some Pieces against the Infinitesimals*, &c.

NIGELLA, FENNEL-FLOWER, or *Devil in a Bush*: A genus of the pentagynia order, belonging to the pentandria class of plants. There is no calyx; the petals are five; and five trifid nectaria within the corolla; there are five connected capsules. There are five species, all of them natives of the warm parts of Europe, and rising from a foot to a foot and an half high, adorned with blue or yellow flowers. They are propagated by seeds, which in a dry and warm situation will thrive very well; and the plants ripen seeds in this country.

NIGER (C. Pescennius Justus), a celebrated governor in Syria, well known by his valour in the Roman armies while but a private man. At the death of Pertinax he was declared emperor of Rome; and his claims to that elevated station were supported by a sound understanding, prudence of mind, moderation, courage, and virtue. He proposed to imitate the actions of the venerable Antoninus, of Trajan, of Titus, and M. Aurelius. He was remarkable for his fondness of ancient discipline. He never suffered his soldiers to drink wine, but obliged them when thirsty to use water and vinegar. He forbade the use of silver or gold utensils in his camp. All the bakers and cooks were driven away, and the soldiers were ordered to live during the expedition they undertook merely upon biscuits. In his punishments Niger was inexorable: he condemned ten of his soldiers to be beheaded in the presence of the army, because they had stolen and eaten a fowl. The sentence was heard with groans. The army interfered; and when Niger consented to diminish the punishment, for fear of kindling rebellion, he yet ordered the criminals to make each a restoration of ten fowls to the person whose property they had stolen. They were besides ordered not to light a fire the rest of the campaign, but to live upon cold aliments and to drink nothing but water. Such great qualifications in a general seemed to promise the restoration of ancient discipline in the Roman armies; but the death of Niger frustrated every hope of reform. Severus, who had also been invested with the imperial purple, marched against him; some battles were fought, and Niger was at last defeated A.D. 195. His head was cut off and fixed to a long spear, and carried in triumph through the streets of Rome. He reigned about a year.

I

NIGER,

Nieuhoff
Niger.

Niger,
Night.

NIGER, a great river of Africa, supposed to have its origin near that of the Nile; but this is very uncertain. We are assured, however, that it is a river of very great extent: especially if we suppose, according to the opinion of the best modern geographers, that it has its source in the kingdom of Gorhan, not far from the confines of Upper Ethiopia; for then it will cross almost the whole continent of Africa, where it is widest. In its course it receives many considerable rivers, which swell it high enough to be able at all times to carry vessels of good burden; it splits itself into several branches, which uniting again form very large and fertile islands, well filled with towns and villages. It passes also through several lakes, and has many cataracts. After having run from east to west during a prodigious long course, it turns at last short to the south, at a league and a half distance from the western ocean; leaving but a very narrow tract between it and the sea, into which it opens its way in lat. 15. 55. after having run about 25 leagues from north to south. Its mouth is sometimes half a league broad; but is shut up by a bank of quick-sand, called the *bar of Senegal*, where the water is so shallow, that it is very difficult and dangerous to pass over it. The bar is formed by the mud and sand which the river brings with it during the inundation, and which the sea continually drives back upon the shore. This would effectually exclude all shipping, had not the violence of the current, and the weight of the waters, made two openings or channels, which are commonly called the *passes of the bar*. The largest of these is generally not above 150 or 200 fathoms broad, and about 10 feet deep, so that none but barks of 40 or 50 tons can get thro' this channel; the other is so narrow and shallow, that it is passable by canoes only. These channels are not always in the same place; for the river, as it is more or less swelled, or the current more or less rapid, opens those passes sometimes in one place and sometimes in another. The bar itself also frequently shifts its place; so that the island of Senegal is sometimes four leagues distant from it, at other times only two. It is this bar only which hinders ships of 400 or 500 tons to go up the river. See GUINEA and NEGROLAND.

NIGHT, that part of the natural day during which the sun is underneath the horizon; or that space wherein it is dusky.

Night was originally divided by the Hebrews and other eastern nations into three parts or watches. The Romans, and after them the Jews, divided the night into four parts or watches; the first of which began at sunset, and lasted till nine at night, according to our way of reckoning; the second lasted till midnight; the third till three in the morning; and the fourth ended at sunrise. The ancient Gauls and Germans divided their time not by days but by nights; and the people of Iceland and the Arabs do the same at this day. The like is observed of the Anglo-Saxons.—The length and shortness of night or of darkness is according to the season of the year and position of the place; and the causes of this variety are now well known. See ASTRONOMY, &c.

NIGHT, in scripture-language, is used for the times of heathenish ignorance and profaneness (Rom. xiii. 12.); for adversity and affliction (Is. xxi. 12.); and, lastly, for death (John ix. 4.)

NIGHT-Angling, a method of catching large and shy fish in the night-time. Trout, and many other of the better sorts of fish, are naturally shy and fearful; they therefore prey in the night as the securest time.—The method of taking them on this plan is as follows: The tackle must be strong, and need not be so fine as for day-fishing, when every thing is seen; the hook must be baited with a large earth-worm, or a black snail, and thrown out into the river; there must be no lead to the line, so that the bait may not sink, but be kept drawling along, upon or near the surface. Whatever trout is near the place will be brought thither by the motion of the water, and will seize the worm or snail. The angler will be alarmed by the noise which the fish makes in rising, and must give him line, and time to swallow the hook; then a slight touch secures him. The best and largest trouts are found to bite thus in the night; and they rise mostly in the still and clear deeps, not in the swift and shallow currents. Sometimes, though there are fish about the place, they will not rise at the bait: in this case the angler must put on some lead to his line, and sink it to the bottom.

NIGHT-Mare, or *Incubus*. See MEDICINE, n° 329.

NIGHT-Walkers, in medicine. See MEDICINE, n° 329, and NOCTAMBULI.

NIGHT-Walkers, in law, are such persons as sleep by day and walk by night, being oftentimes pilferers or disturbers of the public peace. Constables are authorised by the common law to arrest night-walkers and suspicious persons, &c. Watchmen may also arrest night-walkers, and hold them until the morning: and it is said, that a private person may arrest any suspicious night-walker, and detain him till he give a good account of himself. One may be bound to the good behaviour for being a night-walker; and common night-walkers, or haunters of bawdy-houses, are to be indicted before justices of peace, &c. But it is not held lawful for a constable, &c. to take up any woman as a night-walker on bare suspicion only of being of ill fame, unless she be guilty of a breach of the peace, or some unlawful act, and ought to be found mis-doing.

NIGHTINGALE, in ornithology; a species of motacilla. See MOTACILLA, and Plate CCCXV.

The nightingale takes its name from *night*, and the Saxon word *galan*, "to sing;" expressive of the time of its melody. Its size and colour has been described already under MOTACILLA: to which account we add, that its eyes are remarkably large and piercing; and though it is about equal in size to the redstart, it is longer in body, and more elegantly made.

Mr Hunter found, by dissection, that the muscles of the larynx are stronger in the nightingale than in any other bird of the same size.—Sibbald places them in his list of Scotch birds; but they certainly are unknown in that part of Great Britain, probably from the scarcity and the recent introduction of hedges there. Yet they visit Sweden, a much more severe climate. In England they frequent thick hedges, and low coppices; and generally keep in the middle of the bush, so that they are very rarely seen. When the young ones first come abroad, and are helpless, the old birds make a plaintive and jarring noise with a sort

Night-ang-
ling
||
Nightingale.

Nightin-
gale.

of snapping as if in menace, pursuing along the hedge the passengers.

They begin their song in the evening, and continue it the whole night. These their vigils did not pass unnoticed by the ancients: the slumbers of these birds were proverbial; and not to rest as much as the nightingale, expressed a very bad sleeper (A). This was the favourite bird of the British poet, who omits no opportunity of introducing it, and almost constantly noting its love of solitude and night. How finely does it serve to compose part of the solemn scenery of his *Penferoso*; when he describes it

In her saddest sweetest plight,
Smoothing the rugged brow of night;
While *Cynthia* checks her dragon yoke,
Gently o'er th' accustom'd oak.
Sweet bird, that shunn'st the noise of folly,
Most musical, most melancholy!
Thee, chauntress, oft the woods among,
I woo to hear thy evening song.

In another place he styles it the *solemn bird*; and again speaks of it,

As the wakeful bird
Sings darkling, and, in shadiest covert hid,
Tunes her nocturnal note.

The reader will excuse a few more quotations from the same poet, on the same subject; the first describes the approach of evening, and the retiring of all animals to their repose.

Silence accompanied; for beast and bird,
They to their grassy couch, these to their nests,
Were sunk; all but the wakeful nightingale,
She all night long her am'rous descant sung.

When Eve passed the irksome night preceding her fall, she, in a dream, imagines herself thus reproached with losing the beauties of the night by indulging too long a repose.

Why sleep'st thou, *Eve*? now is the pleasant time,
The cool, the silent, save where silence yields
To the night-warbling bird, that now awake
Tunes sweetest his love-labour'd song.

The same birds sing their nuptial song, and lull them to rest. How rapturous are the following lines! how expressive of the delicate sensibility of our Milton's tender ideas!

The earth
Gave sign of gratulation, and each hill;
Joyous the birds; fresh gales and gentle airs
Whisper'd it to the woods, and from their wings
Flung rose, flung odours from the spicy shrub,
Disporting, till the am'rous bird of night
Sung spousal, and bid haste the evening star
On his hill-top to light the bridal lamp.
These, lull'd by nightingales, embracing slept;
And on their naked limbs the flow'ry roof
Shower'd roses, which the morn repair'd.

These quotations from the best judge of melody, we thought due to the sweetest of our feathered choirsters; and we believe no reader of taste will think them tedious.

Virgil seems to be the only poet among the ancients who hath attended to the circumstance of this bird's singing in the night-time.

*Qualis populeâ marens Philomela sub umbrâ
Amisfos queritur fœtus, quos durus arator
Observans nido implumes detrahit: at illa
Flet noctem, ramoque sedens miserabile carmen
Integrat, et mœstis late loca questibus implet.*

Georg. IV. l. 511.

As *Philomel* in poplar shades, alone,
For her lost offspring pours a mother's moan,
Which some rough ploughman marking for his prey,
From the warm nest, unfledg'd, hath dragg'd away;
Perch'd on a bough, she all night long complains,
And fills the grove with sad repeated strains.

F. Warton.

Pliny has described the warbling notes of this bird with an elegance that bespeaks an exquisite sensibility of taste, *lib. x. c. 29*.

If the nightingale is kept in a cage, it often begins to sing about the latter end of November, and continues its song more or less till June.—A young canary-bird, linnet, sky-lark, or robin (who have never heard any other bird), are said best to learn the note of a nightingale.

Mock-NIGHTINGALE. See *MOTACILLA*, sp. 8.

Virginian NIGHTINGALE, in ornithology, the common, but improper, name of a bird of the gros-beaked kind, called by authors the *coccothraustes Indica cristata*.

It is a little smaller than our blackbird; it has a black ring surrounding the eyes and nostrils; the beak is very large and thick, but not altogether so large as in the common gros-beak; and its head is ornamented with a very high and beautiful crest, which it moves about very frequently; it is all over of a very fine and lively red, but paler on the head and tail than elsewhere; it is brought to us from Virginia, and is much valued in England for its beauty and delicate manner of singing; it is very fond of almonds and the like fruits.

NIGHTSHADE, in botany. See *SOLANUM*.

Deadly NIGHTSHADE. See *ATROPA*.—The berries of this plant are of a malignant poisonous nature; and, being of a sweet taste, have frequently proved destructive to children. A large glass of warm vinegar, taken as soon as possible after eating the berries, will prevent their bad effects.

NIGIDIUS FIGULUS (Publius), one of the most learned men of ancient Rome, flourished at the same time with Cicero. He wrote on various subjects; but his pieces appeared so refined and difficult that they were not regarded. He assisted Cicero, with great prudence, in defeating Catiline's conspiracy, and did him many services in the time of his adversity. He

I 2

adhered

(A) *Ælian var. hist. 577*. both in the text and note. It must be remarked, that nightingales sing also in the day.

Nightin-
gale
||
Nigidius.

Nigrina
||
Nile.

adhered to Pompey in opposition to Cæsar; which occasioned his exile, he dying in banishment. Cicero, who had always entertained the highest esteem for him, wrote a beautiful consolatory letter to him (the 13th of *lib. 4. ad Familiares*).

NIGRINA, in botany; a genus of the monogynia order, belonging to the pentandria class of plants. The corolla is funnel-shaped; the calyx inflated; the stigma obtuse; the capsule bilocular.

NIGRITIA. See NEGROLAND.

NIGUA. See CHEGOE.

NILE, a large and celebrated river of Africa, to which the country of Egypt owes its fertility; and the exploring of the sources of which has, from the remotest ages, been accounted an impracticable undertaking. Of late this problem has been solved by James Bruce, Esq; of Kinnaird, in Scotland; who spent several years at the court of Abyssinia, and by the favour of the emperor and great people of the country was enabled to accomplish the arduous task.

In the account of his travels lately published, this gentleman has been at particular pains to show, that none of those who undertook this task ever succeeded in it but himself. The inquiry concerning its springs, he says, began before either history or tradition, and is by some supposed to be the origin of hieroglyphics. Though Egypt was the country which received the greatest benefit from this river, it was not there that the inquiries concerning its inundation began; it being probable that every thing relative to the extent and periodical time of that inundation would be accurately settled (which could not be done but by a long series of observations) before any person would venture to build houses within its reach.

The philosophers of Meroe, in our author's opinion, were the first who undertook to make a number of observations sufficient to determine these points; their country being so situated, that they could perceive every thing relative to the increase or decrease of the river without any danger from its overflowing. Being much addicted to astronomy, it could not long escape them, that the heliacal rising of the dog star was a signal for Egypt to prepare for the inundation; without which it was vain to expect any crop. The connection of this celestial sign with the annual rising of the river would undoubtedly soon become a matter of curiosity; and as this could not easily be discovered, it was natural for an ignorant and superstitious people to ascribe the whole to the action of the dog star as a deity. Still, however, by those who were more enlightened, the phenomenon would be ascribed to natural causes; and a great step towards the discovery of these, undoubtedly was that of the sources of the river itself. In the early ages, when travelling into foreign countries was impracticable by private persons, the inquiry into the sources of the Nile became an object to the greatest monarchs. Sesostris is said to have preferred the honour of discovering them almost to all the victories he obtained. Alexander the Great is well known to have had a great curiosity to discover these fountains. On his arrival at the temple of Jupiter Ammon, he is said to have made inquiry concerning the fountains of the Nile, even before he asked about his own descent from Jupiter. The priests are said to have given him proper directions for finding

them; and Alexander took the most ready means of accomplishing his purpose, by employing natives of Ethiopia to make the search. These discoverers, in the opinion of Mr Bruce, missed their aim, by reason of the turn which the Nile takes to the east in the latitude of 9°, where it begins to surround the kingdom of Gojam; but which they might imagine to be only a winding of the river, soon to be compensated by an equal turn to the west. "They therefore (says he) continued their journey south till near the line, and never saw it more; as they could have no possible notion it had turned back behind them, and that they had left it as far north as latitude 9°. They reported then to Alexander what was truth, that they had ascended the Nile as far south as latitude 9°; where it unexpectedly took its course to the east, and was seen no more. The river was not known, nor to be heard of near the line, or farther southward, nor was it diminished in size, nor had it given any symptom that they were near its source; they had found the Nile *calentem* (warm), while they expected its rise among melting snows."

Mr Bruce is of opinion that this turn of the Nile to the eastward was the occasion of Alexander's extravagant mistake, in supposing that he had discovered the fountains of the Nile when he was near the source of the Indus; and which he wrote to his mother, though he afterwards caused it to be erased from his books.

Ptolemy Philadelphus succeeded Alexander in his attempts to discover the source of the Nile; but he likewise proving unsuccessful, the task was next undertaken by Ptolemy Euergetes, the most powerful of the Greek princes who sat on the throne of Egypt. "In this (says Mr Bruce) he had probably succeeded, had he not mistaken the river itself. He supposed the Siris, now the Tacazze, to be the Nile; and ascending in the direction of its stream, he came to Axum, the capital of Sira and of Ethiopia. But the story he tells of the snow which he found knee-deep on the mountains of Samen, makes me question whether he ever crossed the Siris, or was himself an ocular witness of what he says he observed there."

Cæsar had the same curiosity with other conquerors to visit the springs of the Nile, though his situation did not allow him to make any attempt for that purpose. Nero, however, was more active. He sent two centurions into Ethiopia, with orders to explore the unknown fountains of this river; but they returned without having accomplished their errand. They reported, that, after having gone a long way, they came to a king of Ethiopia, who furnished them with necessaries, and recommendations to some other kingdoms adjacent; passing which, they came to immense lakes, of which nobody knew the end, nor could they ever hope to find it. Their story, however, is by Mr Bruce supposed to be a fiction; as the Nile forms no lakes throughout its course, excepting that of Tzana or Dembea, the limits of which are easily perceived.

No other attempt was made by the ancients to discover the sources of this celebrated river; and the matter was looked upon to be an impossibility, inasmuch that *caput Nili querere* became a proverb, denoting the impossibility of any undertaking. The first who, in more modern ages, made any attempt of this kind

Nile.

Nile. kind was a monk sent into Abyssinia in the year 522, by Nonnosus, ambassador from the Emperor Justin. This monk is called *Cofmas the Hermit*, and likewise *Indoplaustes*, from his supposed travels into India. He proceeded as far as the city of Axum, but did not visit that part of the country where the head of the Nile lies; nor, in Mr Bruce's opinion, would it have been practicable for him to do so. The discovery, however, is said to have been made at last by Peter Paez the missionary. But the truth of this account is denied by Mr Bruce, for the following reasons: 1. "No relation of this kind (says he) was to be found in three copies of Peter Paez's history, to which I had access when in Italy, on my return home. One of these copies I saw at Milan; and, by the interest of friends, had an opportunity of perusing it at my leisure. The other two were at Bologna and Rome. I ran through them rapidly; attending only to the place where the description ought to have been, and where I did not find it: but having copied the first and last page of the Milan manuscript, and comparing them with the two last mentioned, I found that all the three were, word for word, the same, and none of them contained one syllable of the discovery of the source. 2. Alphonso Mendaz came into Abyssinia about a year after Paez's death. New and desirable as that discovery must have been to himself, to the pope, king of Spain, and all his great patrons in Portugal and Italy; though he wrote the history of the country, and of the particulars concerning the mission in great detail and with good judgment, yet he never mentions this journey of Peter Paez, though it probably must have been conveyed to Rome and Portugal after his inspection and under his authority. 3. Balthazar Tellez, a learned Jesuit, has wrote two volumes in folio, with great candour and impartiality, considering the spirit of those times; and he declares his work to be compiled from those of Alphonso Mendez the patriarch, from the two volumes of Peter Paez, as well as from the regular reports made by the individuals of the company in some places, and by the provincial letters in others; to all which he had complete access, as also to the annual reports of Peter Paez, among the rest from 1598 to 1622; yet Tellez makes no mention of such a discovery, though he is very particular as to the merit of each missionary during the long reign of Facilidas, which occupies more than half the two volumes."

The first, and indeed the only account of the fountains of the Nile published before that of Mr Bruce, was Kircher's; who says that he took it from the writings of Peter Paez. The time when the discovery is said to have been made was the 21st of April 1618; at which season the rains are begun, and therefore very unwholesome; so that the Abyssinian armies are not without extreme necessity in the field; between September and February at farthest is the time they are abroad from the capital and in action.

"The river (says Kircher) at this day, by the Ethiopians, is called *Abavy*; it rises in the kingdom of Gojam, in a territory called *Sabala*, whose inhabitants are called *Agows*. The source of the Nile is situated in the west part of Gojam, in the highest part of a valley which resembles a great plain on every side surrounded by high mountains. On the 21st of

April 1618, being here, together with the king and his army, I ascended the place, and observed every thing with great attention: I discovered first two round fountains each about four palms in diameter, and saw, with the greatest delight, what neither Cyrus the Persian, nor Cambyzes, nor Alexander the Great, nor the famous Julius Cæsar, could ever discover. The two openings of these fountains have no issue in the plain on the top of the mountain, but flow from the root of it. The second fountain lies about a stone-cast west from the former: the inhabitants say that this whole mountain is full of water; and add, that the whole plain about the fountain is floating and unsteady, a certain mark that there is water concealed under it; for which reason the water does not overflow at the fountain, but forces itself with great violence out at the foot of the mountain. The inhabitants, together with the emperor, who was then present with his army, maintain, that that year it trembled very little on account of the drought; but in other years, that it trembled and overflowed so that it could scarce be approached without danger. The breadth of the circumference may be about the cast of a sling: below the top of this mountain the people live about a league distant from the fountain to the west; and this place is called *Geesb*; and the fountain seems to be about a cannon-shot distant from *Geesb*; moreover the field where the fountain is, is on all sides difficult of access, except on the north side, where it may be ascended with ease."

On this relation Mr Bruce observes, that there is no such place as *Sabala*; it ought to have been named *Sacala*, signifying the highest ridge of land, where the water falls equally down on both sides, from east and west, or from north and south. So the sharp roofs of our houses, where the water runs down equally on the opposite sides, are called by the same name. Other objections are drawn from the situation of places, and from the number and situation of the fountains themselves, every one of which Mr Bruce found by actual mensuration to be different from Kircher's account. The following, however, he looks upon to be decisive that Paez never was on the spot. "He says, the field in which the fountains of the Nile are, is of very difficult access; the ascent to it being very steep, excepting on the north, where it is plain and easy. Now, if we look at the beginning of this description, we should think it would be the descent, not the ascent, that would be troublesome; for the fountains were placed in a valley, and people rather *descend* into valleys than *ascend* into them; but supposing it was a valley in which there was a field upon which there was a mountain, and on the mountain these fountains; still, I say, that these mountains are nearly inaccessible on the three sides; but that the most difficult of them all is the north, the way we ascend from the plain of Goutto. From the east, by *Sacala*, the ascent is made from the valley of *Litchambara*, and from the plain of *Affoa* to the south you have the almost perpendicular craggy cliff of *Geesb*, covered with thorny bushes, trees, and bamboos, which cover the mouths of the caverns; and on the north you have the mountains of *Aformasha*, thick set with all sorts of thorny trees and shrubs, especially with the *kantuffa*: these thickets are, more-

over,

Nile.

Nile.

over, filled with wild beasts, especially huge, long-haired baboons, which we frequently met walking upright. Through these high and difficult mountains we have only narrow paths, like those of sheep, made by the goats, or the wild beasts we are speaking of, which, after we had walked on them for a long space, landed us frequently at the edge of some valley or precipice, and forced us to go back again to seek a new road. From towards Zeegam to the westward, and from the plain where the river winds so much, is the only easy access to the fountains of the Nile; and they that ascend to them by this way will not even think that approach too easy."

Peter Heyling, a protestant of Lubec, resided several years in the country of Gojam, and was even governor of it, but he never made any attempt to discover the source of the Nile; dedicating himself entirely to a studious and solitary life. The most extraordinary attempt, however, that ever was made to discover the source of this or any other river, was that of a German nobleman named *Peter Joseph de Roux*, comte de Defreval. He had been in the Danish navy from the year 1721; and, in 1739, was made rear-admiral. That same year he resigned his commission, and began his attempt to discover the source of the Nile in Egypt. To this country he took his wife along with him; and had no sooner reached Cairo, than he quarrelled with a Turkish mob on a point of etiquette; which instantly brought upon them the janizaries and guards of police, to take them into custody. The countess exerted herself in an extraordinary manner; and, armed only with a pair of scissors, put all the janizaries to flight, and even wounded several of them; so that her husband was left at liberty to pursue his plan of discovery. To accomplish this, he provided a barge with small cannon, and furnished with all necessary provisions for himself and his wife, who was still to accompany him. Before he set out, however, it was suggested to him, that, supposing government might protect him so far as to allow his barge to pass the confines of Egypt safely, and to the first cataract; supposing also that she was arrived at Ibrim, or Deir, the last garrisons depending on Cairo; yet still some days journey above the garrisons of Deir and Ibrim began the dreadful deserts of Nubia; and farther south, at the great cataract of Jan Adel, the Nile falls 20 feet down a perpendicular rock—so that here his voyage must undoubtedly end. The count, however, flattered himself with being able to obtain such assistance from the garrisons of Ibrim and Deir, as would enable him to take the vessel to pieces, and to carry it up above the cataract, where it could again be launched into the river. To facilitate this scheme he had even entered into a treaty with some of the barbarians named *Kennoufs*, who reside near the cataract, and employ themselves in gathering senna, which abounds in their country. These promised to assist him in this extraordinary adventure; but, luckily for the count, he suffered himself at last to be persuaded by some Venetian merchants at Cairo not to proceed in person on such a dangerous and unheard of navigation, but rather to depute Mr Norden, his lieutenant, who was likewise to serve as his draughtsman to reconnoitre the forts of Ibrim and Deir, as well as

the cataract of Jan Adel, and renew his treaty with the *Kennoufs*. This gentleman accordingly embarked upon one of the vessels common on the Nile, but met with a great many difficulties and disasters before he could reach Syene and the first cataract; after which having with still greater difficulty reached Ibrim, instead of meeting with any encouragement for the count to proceed on his voyage, he was robbed of all he had by the governor of the fort, and narrowly escaped with his life; it having been for some time determined by him and his soldiers, that Mr Norden should be put to death. By these difficulties the count was so much disheartened, that he determined to make no more attempts on the Nubian side. He now resolved to enter Abyssinia by the island of Masuah. With this view he undertook a voyage round the Cape of Good Hope, in order to reach the Red Sea by the straits of Babelmandel: but having begun to use his Spanish commission, and taken two English ships, he was met by commodore Barnet, who made prizes of all the vessels he had with him, and sent home the count himself passenger in a Portuguese ship to Lisbon.

Thus Mr Bruce considers himself as the first European who reached the sources of this river. He informs us that they are in the country of the Agows, as Kircher had said; so that the latter must either have visited them himself, or have had very good information concerning them. The name of the place thro' which is the passage to the territory of the the Agows, is *Abala*; a plain or rather valley, generally about half a mile, and never exceeding a whole mile, in breadth. The mountains which surround it are at first of an inconsiderable height, covered to the very top with herbage and acacia trees; but as they proceed to the southward they become more rugged and woody.—On the top of these mountains are delightful plains, producing excellent pasture. Those to the west join a mountain called *Aformaska*, where, from a direction nearly south-east, they turn south, and inclose the villages and territory of Sacala, which lie at the foot of them; and still lower, that is, more to the westward is the small village of Geesh, where the fountains of the Nile are situated. Here the mountains are in the form of a crescent; and along these the river takes its course. Those which inclose the east side of the plain run parallel to the former in their whole course, making part of the mountains of Lechtambara, or at least joining with them; and these two, when behind Aformaska, turn to the south, and then to the south-west, taking the same form as they do; only making a greater curve, and inclosing them likewise in the form of a crescent, the extremity of which terminates immediately above a small lake named *Gonderoo* in the plain of Affoa, below Geesh, and directly at the fountains of the Nile.

Having passed several considerable streams, all of which empty themselves into the Nile, our traveller found himself at last obliged to ascend a very steep and rugged mountain, where no other path was to be found but a very narrow one made by the sheep or goats, and which in some places was broken, and full of holes; in others, he was obstructed with large stones, which seemed to have remained there since the creation. The whole was covered with thick wood; and he was every where stopped by the kantuffa, as well as by several other thorny plants,

Nile.

Nile. plants, almost as troublesome as that. Having at last, however, reached the top, he had a sight of the Nile immediately below him; but so diminished in size, that it now appeared only a brook scarce sufficient to turn a mill. The village of Geesh is not within sight of the fountains of the river, though not more than 600 yards distant from them. The country about that place terminates in a cliff of about 300 yards high, which reaches down to the plain of Affoa, continuing in the same degree of elevation till it meets the Nile again about 17 miles to the southward, after having made the circuit of the provinces of Gojam and Damot. In the middle of this cliff is a vast cave running straight northward, with many bye-paths forming a natural labyrinth, of sufficient bigness to contain the inhabitants of the whole village with their cattle. Into this Mr Bruce advanced about 100 yards; but he did not choose to go farther, as the candle he carried with him seemed ready to go out; and the people assured him that there was nothing remarkable to be seen at the end. The face of this cliff, fronting the south, affords a very picturesque view from the plain of Affoa below; parts of the houses appearing at every stage through the bushes and thickets of trees. The mouths of the cavern above-mentioned, as well as of several others which Mr Bruce did not see, are hid by almost impenetrable fences of the worst kind of thorn; nor is there any other communication betwixt the upper part and the houses but by narrow winding sheep-paths, very difficult to be discovered; all of them being allowed to be overgrown, as a part of the natural defence of the people. The edge of the cliff is covered with lofty and high trees, which seem to form a natural fence to prevent people from falling down; and the beauty of the flowers which the Abyssinian thorns bear, seems to make some amends for their bad qualities. From the edge of the cliff of Geesh, above where the village is situated, the ground slopes with a descent due north, till we come to a triangular marsh upwards of 86 yards broad, and 286 from the edge of the cliff, and from a priest's house where Mr Bruce resided. On the east, the ground descends with a very gentle slope from the large village of Sacala, which gives its name to the territory, and is about six miles distant from the source, though to appearance not above two. About the middle of this marsh, and not quite 40 yards from the foot of the mountain of Geesh, rises a circular hillock about three feet from the surface of the marsh itself, though founded apparently much deeper in it. The diameter of this hillock is not quite 12 feet, and it is surrounded by a shallow trench which collects the water, and sends it off to the eastward. This is firmly built of sod brought from the sides, and kept constantly in repair by the Agows, who worship the river, and perform their religious ceremonies upon this as an altar. In the midst of it is a circular hole, in the formation or enlargement of which the work of art is evidently discernible. It is always kept clear of grass and aquatic plants, and the water in it is perfectly pure and limpid, but without any ebullition or motion discernible on its surface. The mouth is some parts of an inch less than three feet diameter, and at the time our author first visited it (Nov. 5. 1770), the water stood about two inches from the brim, nor did it either in-

crease or diminish during all the time of his residence at Geesh. On putting down the shaft of a lance, he found a very feeble resistance at six feet four inches, as if from weak rushes and grass; and, about six inches deeper, he found his lance had entered into soft earth, but met with no obstruction from stones or gravel: and the same was confirmed by using a heavy plummet, with a line besmeared with soap.—This is the first fountain of the Nile.

The second fountain is situated at about ten feet distant from the former, a little to the west of south; and is only 11 inches in diameter, but eight feet three inches deep. The third is about 20 feet SSW from the first; the mouth being somewhat more than two feet in diameter, and five feet eight inches in depth. These fountains are made use of as altars, and from the foot of each issues a brisk running rill, which, uniting with the water of the first trench, goes off at the east side in a stream which, our author conjectures, would fill a pipe about two inches diameter. The water of these fountains is extremely light and good, and intensely cold, though exposed to the scorching heat of the sun without any shelter; there being no trees nearer than the cliff of Geesh. The longitude of the principal fountain was found by Mr Bruce to be $36^{\circ} 55' 30''$ E. from Greenwich. The elevation of the ground, according to his account, must be very great, as the barometer stood only at 22 English inches. "Neither (says he) did it vary sensibly from that height any of the following days I staid at Geesh; and thence I inferred, that at the sources of the Nile I was then more than two miles above the level of the sea; a prodigious height, to enjoy a sky perpetually clear, as also a hot sun never overcast for a moment with clouds from rising to setting." In the morning of Nov. 6. the thermometer stood at 44° , at noon 96° , and at sunset 46° . It was sensibly cold at night, and still more so about an hour before sunrise.

The Nile thus formed by the union of streams from these three fountains runs eastward through the marsh for about 30 yards, with very little increase of its water, but still distinctly visible, till it is met by the grassy brink of the land descending from Sacala. By this it is turned gradually NE, and then due north; and in the two miles in which it flows in that direction it receives many small streams from springs on each side; so that about this distance from the fountains it becomes a stream capable of turning a common mill. Our traveller was much taken with the beauty of this spot. "The small rising hills about us (says he) were all thick covered with verdure, especially with clover, the largest and finest I ever saw; the tops of the heights covered with trees of a prodigious size; the stream, at the banks of which we were sitting, was limpid, and pure as the finest crystal; the sod covered thick with a kind of bushy tree, that seemed to affect to grow to no height, but, thick with foliage and young branches, rather to assist the surface of the water; whilst it bore, in prodigious quantities, a beautiful yellow flower, not unlike a single rose of that colour, but without thorns; and indeed, upon examination, we found that it was not a species of the rose, but of the hypericum."

Here Mr Bruce exults greatly in his success; as having

Nile.

Nile. having not only seen the fountains of the Nile, but the river itself running in a small stream; so that the ancient saying of the poet,

Nec licuit populis parvum te Nile videre,

could not be applied to him. Here he *stepped* over it, he says, more than 50 times, though he had told us, in the preceding page, that it was *three yards* over. From this ford, however, the Nile turns to the westward; and, after running over loose stones occasionally in that direction about four miles farther, there is a small cataract of about six feet in height; after which it leaves the mountainous country, and takes its course through the plains of Goutto. Here it flows so gently that its motion is scarcely to be perceived, but turns and winds in its direction more than any river he ever saw; forming more than 20 sharp angular peninsulas in the space of five miles. Here the soil is composed of a marshy clay, quite destitute of trees, and very difficult to travel through; and where its stream receives no considerable addition. Issuing out from thence, however, it is joined by several rivulets which fall from the mountains on each side, so that it becomes a considerable stream, with high and broken banks covered with old timber trees for three miles. In its course it inclines to the north-east, and winds very much, till it receives first a small river named *Diwa*, and then another named *Dee-obba*, or the river *Dec*. Turning then sharply to the east, it falls down another cataract, and about three miles below receives the *Jemma*, a pure and limpid stream, not inferior in size to itself. Proceeding still to the northward, it receives a number of other streams, and at last crosses the southern part of the lake *Tzana* or *Dembea*, preserving the colour of its stream during its passage, and issuing out at the west side of it in the territory of *Dara*.

There is a ford, though very deep and dangerous, at the place where the Nile first assumes the name of a river, after emerging from the lake *Dembea*; but the stream in other places is exceedingly rapid: the banks in the course of a few miles become very high, and are covered with the most beautiful and variegated verdure that can be conceived. It is now confined by the mountains of *Begemder* till it reaches *Alata*, where is the third cataract. This, we are informed by Mr Bruce, is the most magnificent sight he ever beheld; but he thinks that the height has rather been exaggerated by the missionaries, who make it 50 feet; and after many attempts to measure it, he is of opinion that it is nearly 40 feet high. At the time he visited it, the river had been pretty much swelled by rains, and fell in one sheet of water, without any interval, for the space of half an English mile in breadth, with such a noise as stunned and made him giddy for some time. The river, for some space both above and below the fall, was covered with a thick mist, owing to the small particles of the water dashed up into the air by the violence of the shock. The river, though swelled beyond its usual size, retained its clearness, and fell into a natural basin of rock; the stream appearing to run back against the foot of the precipice over which it falls with great violence; forming innumerable eddies, waves, and being in excessive commotion, as may easily be imagined. Jerome Lobo pretends that he was able to reach the foot of the rock, and sit under

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the prodigious arch of water spouting over it; but Mr Bruce does not hesitate to pronounce this to be an absolute falsehood. The noise of the cataract, which, he says, is like the loudest thunder, could not to confound and destroy his sense of hearing; while the rapid motion of the water before his eyes would dazzle the sight, make him giddy, and utterly deprive him of all his intellectual powers. "It was a most magnificent sight (says Mr Bruce), that ages, added to the greatest length of human life, would not deface or eradicate from my memory: it struck me with a kind of stupor, and a total oblivion of where I was, and of every other sublunary concern."

About half a mile below the cataract, the Nile is confined between two rocks, where it runs in a narrow channel with impetuous velocity and great noise. At the village of *Alata* there is a bridge over it, consisting of one arch, and that no more than 25 feet wide. This bridge is strongly fixed into the solid rock on both sides, and some part of the parapets still remain. No crocodiles ever come to *Alata*, nor are any ever seen beyond the cataract.

Below this tremendous water-fall the Nile takes a south-east direction, along the western side of *Begemder* and *Amhara* on the right, inclosing the province of *Gojam*. It receives a great number of streams from both sides, and after several turns takes at last a direction almost due north, and approaches within 62 miles of its source. Notwithstanding the vast increase of its waters, however, it is still fordable at some seasons of the year; and the *Galla* cross it at all times without any difficulty, either by swimming, or on goats-skins blown up like bladders. It is likewise crossed on small rafts, placed on two skins filled with wind; or by twisting their hands round the tails of the horses who swim over; a method always used by the women who follow the Abyssinian armies, and are obliged to cross unfordable rivers. In this part of the river crocodiles are met with in great numbers; but the superstitious people pretend they have charms sufficiently powerful to defend themselves against their voracity.—The Nile now seems to have forced its passage through a gap in some very high mountains which bound the country of the *Ganges*, and falls down a cataract of 280 feet high; and immediately below this are two others, both of very considerable height. These mountains run a great way to the westward, where they are called *Dyre* or *Tegla*, the eastern end of them joining the mountains of *Kueira*, where they have the name of *Fazucllo*. These mountains, our author informs us, are all inhabited by Pagan nations; but the country is less known than any other on the African continent. There is plenty of gold washed down from the mountains by the torrents in the rainy season; which is the fine gold of *Sennaar* named *Tibbar*.

The Nile, now running close by *Sennaar* in a direction nearly north and south, makes afterwards a sharp turn to the east; affording a pleasant view in the fair season, when it is brim-full, and indeed the only ornament of that bare and inhospitable country. Leaving *Sennaar*, it passes by many large towns inhabited by Arabs, all of them of a white complexion; then passing *Gerri*, and turning to the north-east, it joins the *Tacazze*, passing, during its course through this country,

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try a large and populous town named *Chendi*, probably the Candace of the ancients. Here Mr Bruce supposes the ancient island or peninsula of Meroe to have been situated. Having at length received the great river Atbara, the Astaboras of the ancients, it turns directly north for about two degrees; then making a very unexpected turn west by south for more than two degrees in longitude, and winding very little, it arrives at Korti, the first town in Barabra, or kingdom of Dongola. From Korti it runs almost south-west till it passes Dongola, called also *Beja*, the capital of Barabra; after which it comes to Moscho, a considerable town and place of refreshment to the caravans when they were allowed to pass from Egypt to Ethiopia. From thence turning to the north east it meets with a chain of mountains in about $22^{\circ} 15'$ of N. latitude, where is the seventh cataract named *Jan Adel*. This is likewise very tremendous, though not above half as high as that of Alata. This course is now continued till it falls into the Mediterranean; there being only one other cataract in the whole space, which is much inferior to any of those already described.

This very particular and elaborate account of the sources of the Nile and of the course of the river given by Mr Bruce, hath not escaped criticism. We find him accused by the reviewers, not only of having brought nothing to light that was not previously known to the learned, but even of having revealed nothing which was not previously published in Guthrie's *Geographical Grammar*. This, however, seems by no means a fair and candid criticism. If the sources of the Nile, as described by Mr Bruce, were known to the author of Guthrie's *Grammar*, they must likewise have been so to every retailer of geography since the time of the missionaries; which, as the reviewers have particularized that book, would not seem to have been the case. If any thing new was published there previous to the appearance of Mr Bruce's work, it must probably have been derived indirectly from himself; of which clandestine method of proceeding that gentleman has had frequent occasion to complain in other cases. It is alleged, however, that he has given the name of *Nile* to a stream which does not deserve it. This, like all other large rivers, is composed of innumerable branches; to visit the top of every one of which would be indeed an Herculean task. The source of the largest branch therefore, and that which has the longest course, is undoubtedly to be accounted the source of the river; but here it is denied that Mr Bruce had sufficient information. "Of the innumerable streams (say they) that feed the lake of Tzana, there is one that ends in a bog, to which Mr Bruce was conducted by Woldo, a lying guide, who told him it was the source of the Nile. Mr Bruce, in a matter of far less importance, would not have taken Woldo's word; but he is persuaded, that in this case he spoke truth; because the credulous barbarians of the neighbouring district paid something like worship to this brook, which, at the distance of 14 miles from its source, is not 20 feet broad, and nowhere one foot deep. Now it is almost unnecessary to observe, that the natives of that country being, according to Mr Bruce's report, pagans, might be expected to worship the pure and salutary stream; to which, with other extraordinary quali-

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ties, their superstition ascribed the power of curing the bite of a mad dog. Had he traced to its source any of the other rivulets which run into the lake Tzana, it is not unlikely that he might have met with similar instances of credulity among the ignorant inhabitants of its banks. Yet this would not prove any one of them in particular to be the head of the Nile. It would be trifling with the patience of our readers to say one word more on the question, whether the Portuguese Jesuits or Mr Bruce discovered what they erroneously call the head of the Nile. Before either they or he had indulged themselves in a vain triumph over the labours of antiquity, they ought to have been sure that they had effected what antiquity was unable to accomplish. Now the river described by the Jesuit Kircher, who collected the information of his brethren, as well as by Mr Bruce, is not the Nile of which the ancients were in quest. This is amply proved by the prince of modern geographers, the incomparable D'Anville (at least till our own Rennal appeared), in a copious Memoir published in the 26th volume of the *Memoirs of the Academy of Belles Lettres*, p. 45. To this learned dissertation we refer our readers; adding only what seems probable from the writings of Diodorus Siculus and Herodotus, that the ancients had two meanings when they spoke of the head or source of the Nile: First, Literally, the head or source of that great western stream now called the *White River*; which contains a much greater weight of waters, and has a much longer course than the river described by the Jesuits and by Mr Bruce: and, 2dly, Metaphorically, the cause of the Nile's inundation. This cause they had discovered to be the tropical rains, which fall in the extent of 16 degrees on each side of the line; which made the Sacristan of Minerva's temple of Sais in Egypt tell that inquisitive traveller Herodotus, that the waters of the Nile run in two opposite directions from its source; the one north into Egypt, the other south into Ethiopia; and the reports of all travellers into Africa serve to explain and confirm this observation. The tropical rains, they acknowledge, give rise to the Nile and all its tributary streams which flow northward into the kingdom of Sennaar, as well as to the Zeboe, and so many large rivers which flow south into Ethiopia; and then, according to the inclination of the ground, fall into the Indian or Atlantic Ocean. Such then, according to the Egyptian priests, is the true and philosophical source of the Nile; a source discovered above 3000 years ago, and not, as Mr Bruce and the Jesuits have supposed, the head of a paltry rivulet, one of the innumerable streams that feed the lake Tzana."

On this severe criticism, however, it is obvious to remark, that if the source of the Nile had been discovered so many years ago, there is not the least probability that the finding of it should have been deemed an impossible undertaking, which it most certainly was, by the ancients.—That the finding out the fountains of the river itself was an object of their inquiry, cannot be doubted; and from the accounts given by Mr Bruce, it appears very evident that none of the ancients had equal success with himself; though indeed the Jesuits, as has already been observed, seem to have a right to dispute it with him. From the correspondence of his accounts with that of the Jesuits, it

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appears certain that the most considerable stream which flows into the lake Tzana takes its rise from the fountains at Geesh already described; and that it is the most considerable plainly appears from its stream being visible through the whole breadth of the lake, which is not the case with any of the rest. The preference given to this stream by the Agows, who worship it, seems also an incontestible proof that they look upon it to be the great river which passes through Ethiopia and Egypt; nor will the argument of the Reviewers hold good in *supposing* that other streams are worshipped, unless they could prove that they are so. As little can it be any objection or disparagement to Mr Bruce's labours, that he did not discover the sources of the western branch of the Nile called the *White River*. Had he done so, it might next have been objected that he did not visit the springs of the Tacazze, or any other branch. That the origin of the White River was unknown to the ancients may readily be allowed; but so were the fountains of Geesh, as evidently appears from the erroneous position of the sources of the eastern branch of the Nile laid down by Ptolemy. Our traveller, therefore, certainly has the merit, if not of discovering the sources, at least of confirming the accounts which the Jesuits have given of the sources, of the river called the *Nile*; and of which the White River, whether greater or smaller, seems to be accounted only a branch. The superior veneration paid to the eastern branch of this celebrated river will also appear from the variety of names given to it, as well as from the import of these names; of which Mr Bruce gives the following account.

By the Agows it is named *Gzeir*, *Geefa*, or *Seir*; the first of which terms signifies a *god*. It is likewise named *Ab*, father; and has many other names, all of them implying the most profound veneration. Having descended into Gojam it is named *Abay*; which, according to Mr Bruce, signifies the river that suddenly swells and overflows periodically with rain. By the Gongas on the south side of the mountains Dyre and Tagla, it is called *Dabli*, and by those on the north side *Kowafa*; both which names signify a *watching dog*, the *latrator anubis*, or *dog-star*. In the plain country between Fazurlo and Sennaar it is called *Nile*, which signifies *blue*; and the Arabs interpret this name by the word *Azergue*; which name it retains till it reaches Halfaia, where it receives the White River.

Formerly the Nile had the name of *Siris*, both before and after it enters Beja, which the Greeks imagined was given to it on account of its black colour during the inundation; but Mr Bruce assures us that the river has no such colour. He affirms, with great probability, that this name in the country of Beja imports the river of the *dog-star*, on whose vertical appearance this river overflows; "and this idolatrous worship (says he) was probably part of the reason of the question the prophet Jeremiah asks: And what hast thou to do in Egypt to drink the water of Seir, or the water profaned by idolatrous rites?" As for the first, it is only the translation of the word *babar* applied to the Nile. The inhabitants of the Barabra to this day call it *Babar el Nil*, or the sea of the Nile, in contradistinction to the Red Sea, for which they

have no other name than *Babar el Molech*, or the Salt Sea. The junction of the three great rivers, the Nile flowing on the west side of Meroe; the Tacazze, which washes the east side, and joins the Nile at Maggiran in N. Lat. 17°; and the Mareb, which falls into this last something above the junction, gives the name of *Triton* to the Nile.

The name *Ægyptus*, which it has in Homer, and which our author supposes to have been a very ancient name even in Ethiopia, is more difficult to account for. This has been almost universally supposed to be derived from the black colour of the inundation; but Mr Bruce, for the reasons already given, will not admit of this. "Egypt (says he) in the Ethiopic is called *y Gipt*, Agar; and an inhabitant of the country, *Gypt*, for precisely so it is pronounced; which means the country of ditches or canals, drawn from the Nile on both sides at right angles with the river: nothing surely is more obvious than to write *y Gipt*, so pronounced, *Egypt*; and, with its termination *us* or *os*, *Egyptus*. The Nile is also called *Kronides*, Jupiter; and has had several other appellations bestowed upon it by the poets; though these are rather of a transitory nature than to be ranked among the ancient names of the river. By some of the ancient fathers it has been named *Geon*; and by a strange train of miracles they would have it to be one of the rivers of the terrestrial paradise; the same which is said to have encompassed the whole land of Cush or Ethiopia. To effect this, they are obliged to bring the river a great number of miles, not only under the earth, but under the sea also; but such reveries need no refutation."

Under the article EGYPT we have so fully explained the cause of the annual inundation of the Nile, that, with regard to the phenomena itself, nothing farther seems necessary to be added. We shall therefore only extract from Mr Bruce's work what he has said concerning the mode of natural operation by which the tropical rains are produced; which are now universally allowed to be the cause of the annual overflowing of this and other rivers.

According to this gentleman, the air is so much rarefied by the sun during the time that he remains almost stationary over the tropic of Capricorn, that the other winds loaded with vapours rush in upon the land from the Atlantic ocean on the west, the Indian ocean on the east, and the cold Southern ocean beyond the Cape. Thus a great quantity of vapour is gathered, as it were, into a focus; and as the same causes continue to operate during the progress of the sun northward, a vast train of clouds proceed from south to north, which, Mr Bruce informs us, are sometimes extended much farther than at other times. Thus he tells us, that for two years some white dappled clouds were seen at Gondar on the 7th of January; the sun being then 34° distant from the zenith, and not the least cloudy speck having been seen for several months before. About the first of March, however, it begins to rain at Gondar, but only for a few minutes at a time, in large drops; the sun being then about 5° distant from the zenith. The rainy season commences with violence at every place when the sun comes directly over it; and before it commences at Gondar, green boughs and leaves appear floating in the Bahar el Abiad,

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Nile. or White River, which, according to the accounts given by the Galla, our author supposes to take its rise in about 5° north latitude.

The rains therefore precede the sun only about 5°; but they continue and increase after he has passed it. In April all the rivers in the southern parts of Abyssinia begin to swell, and greatly augment the Nile, which is now also farther augmented by the vast quantity of water poured into the lake Tzana. On the first days of May, the sun passes the village of Gerri, which is the limit of the tropical rains; and it is very remarkable, that, though the sun still continues to operate with unabated vigour, all his influence cannot bring the clouds farther northward than this village; the reason of which Mr Bruce, with great reason, supposes to be the want of mountains to the northward. In confirmation of this opinion, he observes, that the tropical rains stop at the latitude of 14° instead of 16° in the western part of the continent. All this time, however, they continue violent in Abyssinia; and in the beginning of June the rivers are all full, and continue so while the sun remains stationary in the tropic of Cancer.

This excessive rain, which would sweep off the whole soil of Egypt into the sea were it to continue without intermission, begins to abate as the sun turns southward; and on his arrival at the zenith of each place, on his passage towards that quarter, they cease entirely: the reason of which is no less difficult to be discovered than that of their coming on when he arrives at the zenith in his passage northward. Be the reason what it will, however, the fact is certain; and not only so, but the time of the rains ceasing is exact to a single day; inasmuch, that on the 25th of September the Nile is generally found to be at its highest at Cairo, and begins to diminish every day after. Immediately after the sun has passed the line, he begins the rainy season to the southward; the rains constantly coming on with violence as he approaches the zenith of each place; but the inundation is now promoted in a different manner, according to the difference of circumstances in the situation of the places. From about 6° S. Lat. a chain of high mountains runs all the way along the middle of the continent towards the Cape of Good Hope, and intersects the southern part of the peninsula nearly in the same manner that the Nile does the northern. A strong wind from the south, stopping the progress of the condensed vapours, dashes them against the cold summits of this ridge of mountains, and forms many rivers, which escape in the direction either of east or west as the level presents itself. If this is towards the west, they fall down the sides of the mountains into the Atlantic, and if on the east into the Indian ocean.—“The clouds (says Mr Bruce), drawn by the violent action of the sun, are condensed, then broken, and fall as rain on the top of this high ridge, and swell every river; while a wind from the ocean on the east blows like a monsoon up each of these streams, in a direction contrary to their current, during the whole time of the inundation; and this enables boats to ascend into the western parts of Sofala, and the interior country to the mountains, where lies the gold. The same effect, from the same cause, is produced on the western side towards the Atlantic; the high ridge of mountains being placed be-

between the different countries west and east, is at once the source of their riches, and of those rivers which conduct to the treasures, which would be otherwise inaccessible, in the eastern parts of the kingdoms of Benin, Congo, and Angola.

“There are three remarkable appearances attending the inundation of the Nile. Every morning in Abyssinia is clear, and the sun shines. About nine, a small cloud, not above four feet broad, appears in the east, whirling violently round as if upon an axis; but, arrived near the zenith, it first abates its motion, then loses its form, and extends itself greatly, and seems to call up vapours from all the opposite quarters. These clouds having attained nearly the same height, rush against each other with great violence, and put me always in mind of Elisha foretelling rain on mount Carmel. The air impelled before the heaviest mass, or swiftest mover, makes an impression of its form on the collection of clouds opposite; and the moment it has taken possession of the space made to receive it, the most violent thunder possible to be conceived instantly follows, with rain: after some hours the sky again clears, with a wind at north; and it is always disagreeably cold when the thermometer is below 63°.

“The second thing remarkable is the variation of the thermometer. When the sun is in the southern tropic, 36° distant from the zenith of Gondar, it is seldom lower than 72°; but it falls to 60°, and 63°, when the sun is immediately vertical; so happily does the approach of rain compensate the heat of a too scorching sun.

“The third is that remarkable stop in the extent of the rain northward, when the sun, that has conducted the vapours from the line, and should seem now more than ever to be in possession of them, is here over-ruled suddenly; till, on its return to Gorri, again it resumes the absolute command over the rain, and reconducts it to the Line, to furnish distant deluges to the southward.”

With regard to the Nile itself, it has been said that the quantity of earth brought down by it from Abyssinia is so great, that the whole land of Egypt is produced from it. This question, however, is discussed under the article EGYPT, where it is shown that this cannot possibly be the case.—Among other authorities there quoted was that of Mr Volney, who strenuously argues against the opinion of Mr Savary and others, who have maintained that Egypt is the gift of the Nile. Notwithstanding this, however, we find him asserting that the soil of Egypt has undoubtedly been augmented by the Nile: in which case it is not unreasonable to suppose that it has been produced by it altogether.—“The reader (says he) will conclude, doubtless, from what I have said, that writers have flattered themselves too much in supposing they could fix the precise limits of the enlargement and rise of the Delta. But, though I would reject all illusory circumstances, I am far from denying the fact to be well founded; it is too plain from reason, and an examination of the country. The rise of the ground appears to me demonstrated by an observation on which little stress has been laid. In going from Rosetta to Cairo, when the waters are low, as in the month of March, we may remark, as we go up the river, that the shore rises gradually above the water; so that if it overflowed

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two feet at Rosetta, it overflows from three to four at Faoua, and upwards of twelve at Cairo (A). Now by reasoning from this fact, we may deduce the proof of an increase by sediment; for the layer of mud being in proportion to the thickness of the sheets of water by which it is deposited, must be more or less considerable as these are of a greater or less depth; and we have seen that the like gradation is observable from Asouan to the sea.

"On the other hand, the increase of the Delta manifests itself in a striking manner, by the form of Egypt along the Mediterranean. When we consider its figure on the map, we perceive that the country which is in the line of the river, and evidently formed of foreign materials, has assumed a semicircular shape, and that the shores of Arabia and Africa, on each side, have a direction towards the bottom of the Delta; which manifestly discovers that this country was formerly a gulf, that in time has been filled up.

"This accumulation is common to all rivers, and is accounted for in the same manner in all: the rain water and the snow descending from the mountains into the valleys, hurry incessantly along with them the earth they wash away in their descent. The heavier parts, such as pebbles and sands, soon stop, unless forced along by a rapid current. But when the waters meet only with a fine and light earth, they carry away large quantities with the greatest facility. The Nile, meeting with such a kind of earth in Abyssinia and the interior parts of Africa, its waters are loaded and its bed filled with it; nay, it is frequently so embarrassed with this sediment as to be straitened in its course. But when the inundation restores to it its natural energy, it drives the mud that has accumulated toward the sea, at the same time that it brings down more for the ensuing season; and this, arrived at its mouth, heaps up, and forms shoals, where the declivity does not allow sufficient action to the current, and where the sea produces an equilibrium of resistance. The stagnation which follows occasions the grosser particles, which till then had floated, to sink; and this takes place more particularly in those places where there is least motion, as towards the shores, till the sides become gradually enriched by the spoils of the upper country and of the Delta itself; for if the Nile takes from Abyssinia to give to the Thebais, it likewise takes from the Thebais to give to the Delta, and from the Delta to carry to the sea. Wherever its waters have a current, it despoils the same territory that it enriches. As we ascend towards Cairo, when the river is low, we may observe the banks worn steep on each side and crumbling in large flakes. The Nile, which undermines them, depriving their light earth of support, it falls into the bed of the river; for when the water is high, the earth imbibes it; and when the sun and drought return, it cracks and moulders away in great flakes, which are hurried along by the Nile."

Thus does Mr Volney argue for the increase of the Delta in the very same manner that others have argued for the production of the whole country of

Egypt; an opinion which he is at great pains to refute. Under the article EGYPT, however, it is shown that the Nile does not bring down any quantity of mud sufficient for the purposes assigned; and with regard to the argument drawn from the shallowness of the inundation when near the sea, this does not prove any rise of the land; but, as Mr Renel has judiciously observed in his remarks on the inundation of the Ganges, arises from the nature of the fluid itself. The reason, in short, is this: The surface of the sea is the lowest point to which the waters of every inundation have a tendency; and when they arrive there, they spread themselves over it with more ease than any where else, because they meet with less resistance. Their motion, however, by reason of the small declivity, is less swift than that of the waters farther up the river, where the declivity is greater; and consequently the latter being somewhat impeded in their motion, are in some degree accumulated. The surface of the inundation, therefore, does not form a perfectly level plain, but one gradually sloping from the interior parts of the country towards the sea; so that at the greatest distance from the ocean the water will always be deepest, even if we should suppose the whole country to be perfectly smooth, and composed of the most solid materials.—This theory is easily understood from observing a quantity of water running along a wooden spout, which is always more shallow at the end of the spout where it runs off than at the other.—With regard to Mr Volney's other arguments, they are without doubt contradictory; for if, as he says, the river takes from Abyssinia to give to the Thebais, from Thebais to give to the Delta, and from Delta to the sea, it undoubtedly follows, that it gives nothing to any part of the land whatever, but that altogether is swept into the Mediterranean sea; which, indeed, some very trifling quantities excepted, is most probably the case.

It has been remarked by Mr Pococke, a very judicious traveller, that, in the beginning of the inundation, the waters of the Nile turn red, and sometimes green; and while they remain of that colour, they are unwholesome. He explains this phenomenon by supposing, that the inundation at first brings away that red or green filth which may be about the lakes where it takes its rise; or about the sources of the small rivers which flow into it, near its principal source; "for," says he, though there is so little water in the Nile when at lowest, that there is hardly any current in many parts of it, yet it cannot be supposed that the water should stagnate in the bed of the Nile so as to become green. Afterwards the water begins to be red and still more turbid, and then it begins to be wholesome."—This circumstance is explained by Mr Bruce in the following manner. The country about Narea and Caffa, where the river Abiad takes its rise, is full of immense marshes, where, during the dry season, the water stagnates, and becomes impregnated with every kind of corrupted matter. These, on the commencement of the rains, overflow into the river Abiad, which takes its rise there. The overflowing of

Nile.

(A) "It would be curious to ascertain in what proportion it continues up to Asouan. Some Copts, whom I have interrogated on the subject, assured me that it was much higher through all the Said than at Cairo."

Nile.

of these vast marshes first carry the discoloured water into Egypt; after which follows that of the great lake Tzana, through which the Nile passes; which having been stagnated, and without rain, under a scorching sun for six months, joins its putrid waters to the former. In Abyssinia also, there are very few rivers that run after November, but all of them stand in prodigious pools, which, by the heat of the sun, likewise turn putrid, and on the commencement of the rains throw off their stagnant water into the Nile; but at last, the rains becoming constant, all this putrid matter is carried off, and the sources of the inundation, become sweet and wholesome. The river then passing thro' the kingdom of Sennaar, the soil of which is a red bole, becomes coloured with that earth; and this mixture, along with the moving sands of the deserts, of which it receives a great quantity when raised by the wind, precipitates all the viscous and putrid matters which float in the waters; whence Mr Pocock judiciously observes, that the Nile is not wholesome when the water is clear and green, but when so red and turbid that it stains the water of the Mediterranean.

The rains in Abyssinia, which cease about the 8th of September, generally leave a sickly season in the low country; but the diseases produced by these rains are removed by others which come on about the end of October, and cease about the 8th of November. On these rains depend the latter crops of the Abyssinians; and for these the Agows pray to the river, or the genius or spirit residing in it. In Egypt, however, the effect of them is seldom perceived; but in some years they prove excessive: and it has been observed that the Nile, after it has fallen, has again risen in such a manner as to alarm the whole country. This is said to have happened in the time of Cleopatra, when it was supposed to presage the extinction of the government of the Ptolemies; and in 1737 it was likewise imagined to portend some dreadful calamity.

The quantity of rain, by which all this inundation is occasioned, varies considerably in different years; at least at Gondar, where Mr Bruce had an opportunity of measuring it. In 1770 it amounted to 35½ inches; but in 1771 it amounted to no less than 41.355 inches from the vernal equinox to the 8th of September.—What our author adds concerning the variation of the rainy months seems totally irreconcilable with what he had before advanced concerning the extreme regularity of the natural causes by which the tropical rains are produced. “In 1770 (says he) August was the rainy month; in 1771, July.—When July is the rainy month, the rains generally cease for some days in the beginning of August, and then a prodigious deal falls in the latter end of that month and first week of September. In other years July and August are the violent rainy months, while June is fair. And lastly, in others, May, June, July, August, and the first week of September.”—If this is the case, what becomes of the regular attraction of the clouds by the sun as he advances northward; of the coming on of the rains when he arrives at the zenith of any place, in his passage to the tropic of Cancer; and of their ceasing when he comes to the same point in his return southward?

Under the article ETHIOPIA we have mentioned a threat of one of the Abyssinian monarchs, that he

would direct the course of the Nile and prevent it from fertilizing the land of Egypt; and it has likewise been related, that considerable progress was made in this undertaking by another emperor. Mr Bruce has bestowed an entire chapter on the subject; and is of opinion, that “there seems to be no doubt that it is possible to diminish or divert the course of the Nile, that it should be insufficient to fertilize the country of Egypt; because the Nile, and all the rivers that run into it, and all the rains that swell these rivers, fall in a country two miles above the level of the sea; therefore it cannot be denied, that there is level enough to divert many of the rivers into the Red Sea, or perhaps still easier by turning the course of the river Abiad till it meets the level of the Niger, or pass through the desert into the Mediterranean.”—Alphonso Albuquerque is said to have written frequently to the king of Portugal to send him pioneers from Madeira, with people accustomed to level grounds, and prepare them for sugar canes; by whose assistance he meant to turn the Nile into the Red Sea. This undertaking, however, if it really had been projected, was never accomplished; nor indeed is there any probability that ever such a mad attempt was proposed. Indeed, though we cannot deny that there is a possibility in nature of accomplishing it, yet the vast difficulty of turning the course of so many large rivers may justly stigmatize it as impracticable; not to mention the obstacles which must naturally be suggested from the apparent inutility of the undertaking, and which would arise from the opposition of the Egyptians.

It has already been observed in a quotation from the Reviewers, that Herodotus was informed by the sacristan or secretary of the treasury of Minerva, that one half of the waters of the Nile ran north and the other south. This is also taken notice of by Mr Bruce; who gives the following explanation of it. “The secretary was probably of that country himself, and seems by his observation to have known more of it than all the ancients together. In fact we have seen, that between 13° and 14° north latitude, the Nile, with all its tributary streams, which have their rise and course within the tropical rains, falls down into the flat country (the kingdom of Sennaar), which is more than a mile lower than the high country in Abyssinia; and thence, with a little inclination, it runs into Egypt. Again, in latitude 9°, in the kingdom of Gingiro, the Zebec runs south or south-east, into the Inner Ethiopia, as do also many other rivers, and, as I have heard from the natives of that country, empty themselves into a lake, as those on the north side of the line do into the lake Tzana, thence distributing their waters to the east and west. These become the heads of great rivers, that run through the interior countries of Ethiopia (corresponding to the sea-coast of Melinda and Mombaza) into the Indian Ocean; whilst, on the westward, they are the origin of the vast streams that fall into the Atlantic, passing through Benin and Congo, southward of the river Gambia and the Sierra-leona. In short, the periodical rains from the tropic of Capricorn to the line, being in equal quantity with those that fall between the line and the tropic of Cancer, it is plain, that if the land of Ethiopia sloped equally from the line southward and northward, the rains that fall would

Nile.

Nile.

go, the one half north and the other half south; but as the ground from 5° north declines all southward, it follows, that the rivers which run to the southward must be equal to those that run northward, *plus* the rain that falls in the 5° north latitude, where the ground begins to slope to the southward; and there can be little doubt that this is at least one of the reasons why there are in the southern continent so many rivers larger than the Nile, that run both into the Indian and Atlantic Oceans."

From this account given to Herodotus, it has been supposed, by some writers on geography, that the Nile divides itself into two branches, one of which runs northward into Egypt, and one through the country of the negroes westward into the Atlantic ocean. This opinion was first broached by Pliny. It has been adopted by the Nubian geographer, who urges in support of it, that if the Nile carried down all the rains which fall into it from Abyssinia, the people of Egypt would not be safe in their houses. But to this Mr Bruce answers, that the waste of water in the burning deserts through which the Nile passes is so great, that unless it was supplied by another stream, the White river, equal in magnitude to itself, and which, rising in a country of perpetual rains, is thus always kept full, it never could reach Egypt at all, but would be lost in the sands, as is the case with many other very considerable rivers in Africa. "The rains (says he) are collected by the four great rivers in Abyssinia; the Mareb, the Bowiha, the Tacazze, and the Nile. All these principal, and their tributary streams, would, however, be absorbed, nor be able to pass the burning deserts, or find their way into Egypt, were it not for the White river, which having its source in a country of almost perpetual rains, joins to it a never-failing stream equal to the Nile itself."

We shall conclude this article with some account of the Agows who inhabit the country about the sources of the Nile. These, according to Mr Bruce, are one of the most considerable nations in Abyssinia, and can bring into the field about 4000 horse and a great number of foot; but were once much more powerful than they are now, having been greatly reduced by the invasions of the Galla. Their province is nowhere more than 60 miles in length, or than 30 in breadth; notwithstanding which they supply the capital and all the neighbouring country with cattle, honey, butter, wax, hides, and a number of other necessary articles; whence it has been customary for the Abyssinian princes to exact a tribute rather than military service from them. The butter is kept from putrefaction during the long carriage, by mixing it with a small quantity of a root somewhat like a carrot, which they call *mormoco*. It is of a yellow colour, and answers the purpose perfectly well; which in that climate it is very doubtful if salt could do. The latter is besides used as money; being circulated instead of silver coin, and used as change for gold. Brides paint their feet, hands, and nails, with this root. A large quantity of the seed of the plant was brought into Europe by Mr Bruce.

The Agows carry on a considerable trade with the Shangalla and other black savages in the neighbourhood; exchanging the produce of their country for

gold, ivory, horns of the rhinoceros, and some fine cotton. The barbarity and thievish disposition of both nations, however, render this trade much inferior to what it might be.

In their religion the Agows are gross idolators, paying divine honours to the Nile, as has already been observed. Mr Bruce, who lodged in the house of the priest of the river, had an opportunity of becoming acquainted with many particulars of their devotion. He heard him address a prayer to the Nile, in which he styled it the "Most High God, the Saviour of the world." In this prayer he petitioned for seasonable rain, plenty of grass, and the preservation of a kind of serpents; deprecating thunder also very pathetically. The most sublime and lofty titles are given by them to the spirit which they suppose to reside in the river Nile; calling it everlasting God, Light of the world, Eye of the World, God of Peace, their Saviour, and Father of the Universe.

The Agows are all clothed in hides, which they manufacture in a manner peculiar to themselves. These hides are made in the form of a shirt reaching down to their feet, and tied about the middle with a kind of sash or girdle. The lower part of it resembles a large double petticoat; one fold of which they turn back over their shoulders, fastening it with a broach or skewer across their breast before, and the married women carry their children in it behind. The younger sort generally go naked. The women are marriageable at nine years of age, though they commonly do not marry till eleven; and they continue to bear children till 30, and sometimes longer. They are generally thin, and below the middle size, as well as the men. Barrenness is quite unknown among them.

The country of the Agows has a very elevated situation, and is of course so temperate that the heat may easily be borne, though little more than 10° from the equator. The people, however, are but short-lived; which may in part be owing to the oppression they labour under. This, according to Mr Bruce, is excessive. "Though their country (says he) abounds with all the necessaries of life, their taxes, tributes, and services, especially at present, are so multiplied upon them, whilst their distresses of late have been so great and frequent, that they are only the manufacturers of the commodities they sell, to satisfy these constant exorbitant demands, and cannot enjoy any part of their own produce themselves, but live in penury and misery scarce to be conceived. We saw a number of women wrinkled and sun-burnt so as scarce to appear human, wandering about under a burning sun, with one and sometimes two children upon their backs; gathering the seeds of bent grass to make a kind of bread."

NILOMETER, or NILOSCOPE, an instrument used among the ancients to measure the height of the water of the river Nile in its overflowings.

The word comes from *Νίλος*, Nile (and that from *νεα ἰλος*, "new mud," or, as some others will have it, from *νεω*, "I flow," and *ἰλος*, "mud,") and *μετρον*, "measure." The Greeks more ordinarily call it *Νειλοσκοπιον*.

The nilometer is said, by several Arabian writers, to have been first set up, for this purpose, by Joseph during his regency in Egypt: the measure of it

Nile,
Nilometer.

Nilometer. was 16 cubits, this being the height of the increase of the Nile, which was necessary to the fruitfulness of Egypt.

† *Scripture weights and measures,* p. 18. From the measure of this column, Dr Cumberland † deduces an argument, in order to prove that the Jewish and Egyptian cubit were of the same length.

In the French king's library is an Arabic treatise on nilometers, intitled *Neil fi alnal al Nil*; wherein are described all the overflowings of the Nile, from the first year of the Hegira to the 875th.

Herodotus mentions a column erected in a point of the island Delta, to serve as a nilometer; and there is still one of the same kind in a mosque of the same place.

As all the riches of Egypt arise from the inundations of the Nile, the inhabitants used to supplicate them at the hands of their Serapis; and committed the most execrable crimes, as actions, forsooth, of religion, to obtain the favour. This occasioned Constantine expressly to prohibit these sacrifices, &c. and to order the nilometer to be removed into the church; whereas, till that time, it had been in the temple of Serapis. Julian the apostate had it replaced in the temple, where it continued till the time of the great Theodosius.

* *Bruce's Travels,* vol. 3. The only rational and consistent account, however, which we have of the nilometer is given by the celebrated traveller Mr Bruce. "On the point * of the island Rhode, between Geeza and Cairo, near the middle of the river, is a round tower inclosing a neat well or cistern lined with marble. The bottom of this well is on the same level with the bottom of the Nile, which has free access to it through a large opening like an embrasure. In the middle of the well rises a thin column of eight faces of blue and white marble; of which the foot is on the same plane with the bottom of the river. This pillar is divided into 20 pecks, of 22 inches each. Of these pecks the two lowermost are left, without any division, to stand for the quantity of sludge which the water deposits there. Two pecks are then divided, on the right-hand, into 24 digits each; then on the left, four pecks are divided into 24 digits; then on the right, four; and on the left another four: again, four on the right, which completes the number of 18 pecks from the first division marked on the pillar, each peck being 22 inches. Thus the whole marked and unmarked amounts to something more than 36 feet English.

On the night of St John, when, by the falling of the dew, they perceive the rain-water from Ethiopia mixed with the Nile at Cairo, they begin to announce the elevation of the river, having then five pecks of water marked on the nilometer, and two unmarked for the sludge, of which they take no notice. Their first proclamation, supposing the Nile to have risen 12 digits, is 12 from 6, or it wants 12 digits to be six pecks. When it has risen three more, it is nine from six; and so on, till the whole 18 be filled, when all the land of Egypt is fit for cultivation. Several canals are then opened, which convey the water into the desert, and hinder any further stagnation on the fields. There is indeed a great deal of more water to come from Ethiopia; but were the inundation suffered to go on, it would not drain soon enough to fit the land for tillage: and to guard against this mis-

chief is the principal use of the nilometer, though the Turkish government makes it an engine of taxation. From time immemorial the Egyptians paid, as tribute to the king, a certain proportion of the fruit of the ground; and this was anciently ascertained by the elevation of the water on the nilometer, and by the mensuration of the land actually overflowed. But the Saracen government, and afterwards the Turkish, has taxed the people by the elevation alone of the water, without attending to its course over the country, or the extent of the land actually overflowed; and this tax is sometimes cruelly oppressive.

NIMBUS, in antiquity, a circle observed on certain medals, or round the heads of some emperors; answering to the circles of light drawn round the images of saints.

NIMEGUEN, a large, handsome, and strong town of the Netherlands, and capital of Dutch Guelderland, with a citadel, an ancient palace, and several forts. It is noted for the peace concluded there in 1679. It has a magnificent town-house, and the inhabitants are greatly given to trade. It is seated on the Vahal or Wahal, between the Rhine and the Maese. It is the utmost eastern boundary of the Netherlands. It contains two Dutch churches, a French Calvinist and a Lutheran church, five Popish, and several hospitals. It was once a Hans-town and an imperial city. It is now the seat of government, has a canal to Arnheim, and considerable trade to some parts of Germany: it trades also in fine beer-brewing, fattening of cattle, and exporting of its butter, which is extremely good, into all the other provinces. It is in E. Long. 5. 50. N. Lat. 51. 55.

NIMETULAHITES, a kind of Turkish monks, so called from their founder Nimetulahi, famous for his doctrines and the austerity of his life.

NIMPO, a city and sea-port town of China, in the province of Chekiang. It is seated on the eastern sea of China, over-against Japan. It is a city of the first rank, and stands at the confluence of two small rivers, which, after their union, form a channel that reaches to the sea, and is deep enough to bear vessels of 200 tons burden. The walls of Nimpo are 5000 paces in circumference, and are built with free-stone. There are five gates, besides two water-gates for the passage of barks into the city; a tower several stories high, built of bricks; and a long bridge of boats, fastened together with iron chains, over a very broad canal. This city is commanded by a citadel built on a very high rock, by the foot of which all vessels must necessarily pass. The Chinese merchants of Siam and Batavia go to this place yearly to buy silks, which are the finest in the empire. They have also a great trade with Japan, it being but two days sail from hence: thither they carry silks, stuffs, sugar, drugs, and wine; and bring back copper, gold, and silver. E. Long. 122. 0. N. Lat. 30. 0.

NIMROD, the sixth son of Cush, and in all appearance much younger than any of his brothers: for Moses mentions the sons of Raamah, his fourth brother, before he speaks of him. What the sacred historian says of him is short; and yet he says more of him than of any other of the posterity of Noah, till he comes to Abraham. He tells us, that "Nimrod began to be a mighty one in the earth;" that he was

Nimbus
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Nimrod.

Nimrod.

a "mighty hunter before the Lord," even to a proverb; and that "the beginning of his kingdom was Babel, and Erech, and Accad, and Calneh, in the land of Shinaar."

From this account he is supposed to have been a man of extraordinary strength and valour. Some represent him as a giant; all consider him as a great warrior. It is generally thought, that by the words a *mighty hunter*, is to be understood, that he was a great tyrant; but some of the rabbins interpret those words favourably, saying, that Nimrod was qualified by a peculiar dexterity and strength for the chase, and that he offered to God the game which he took; and several of the moderns are of opinion, that this passage is not to be understood of his tyrannical oppressions, or of hunting of men, but of beasts. It must be owned, that the phrase *before the Lord* may be taken in a favourable sense, and as a commendation of a person's good qualities; but in this place the generality of expositors understand it otherwise.

Hunting must have been one of the most useful employments in the times just after the dispersion, when all countries were over-run with wild beasts, of which it was necessary they should be cleared, in order to make them habitable; and therefore nothing seemed more proper to procure a man esteem and honour in those ages, than his being an expert hunter. By that exercise, we are told, the ancient Persians fitted their kings for war and government; and hunting is still, in many countries, considered as one part of a royal education.

There is nothing in the short history of Nimrod which carries the least air of reproach, except his name, which signifies a *rebel*; and that is the circumstance which seems to have occasioned the injurious opinions which have been entertained of him in all ages. Commentators, being prepossessed in general, that the curse of Noah fell upon the posterity of Ham, and finding this prince stigmatized by his name, have interpreted every passage relating to him to his disadvantage. They represent him as a rebel against God, in persuading the descendants of Noah to disobey the divine command to disperse, and in setting them to build the tower of Babel, with an impious design of scaling heaven. They brand him as an ambitious usurper, and an insolent oppressor; and make him the author of the adoration of fire, of idolatrous worship given to men, and the first persecutor on the score of religion. On the other hand, some account him a virtuous prince, who, far from advising the building of Babel, left the country, and went into Assyria, because he would not give his consent to that project.

Nimrod is generally thought to have been the first king after the flood; though some authors, supposing a plantation or dispersion prior to that of Babel, have made kings in several countries before his time. Mizraim is thought by many who contend for the antiquity of the Egyptian monarchy, to have begun his reign much earlier than Nimrod; and others, from the uniformity of the languages spoken in Assyria, Babylonia, Syria, and Canaan, affirm those countries to have been peopled before the confusion of tongues.

The four cities Moses gives to Nimrod constituted a large kingdom in those early times, when few kings had more than one; only it must be observed, that

N^o 242.

possessions might at first have been large, and afterwards divided into several parcels; and Nimrod being the leader of a nation, we may suppose his subjects settled within those limits: whether he became possessed of those cities by conquest or otherwise, does not appear; it is most probable he did not build Babel, all the posterity of Noah seeming to have been equally concerned in that affair; nor does it appear that he built the other three, though the founding of them, and many more, with other works, are attributed to him by some authors. It may seem also a little strange, that Nimrod should be preferred to the regal dignity, and enjoy the most cultivated part of the earth then known, rather than any other of the elder chiefs or heads of nations, even of the branch of Ham. Perhaps it was conferred on him for his dexterity in hunting; or, it may be, he did not assume the title of king till after his father Cush's death, who might have been settled there before him, and left him the sovereignty; but we incline to think, that he seized Shinaar from the descendants of Shem, driving out Ashur, who from thence went and founded Nineveh and other cities in Assyria.

The scripture does not inform us when Nimrod began his reign: Some date it before the dispersion; but such a conjecture does not seem to suit with the Mosaic history: for before the dispersion we read of no city but Babel; nor could there well be more, while all mankind were yet in a body together; but when Nimrod assumed the regal title, there seem to have been other cities; a circumstance which shows it was a good while after the dispersion. The learned writers of the Universal History place the beginning of his reign 30 years from that event, and in all likelihood it should be placed rather later than earlier.

Authors have taken a great deal of pains to find Nimrod in profane history: some have imagined him to be the same with Belus, the founder of the Babylonish empire; others take him to be Ninus, the first Assyrian monarch. Some believe him to have been Evechous, the first Chaldean king after the deluge; and others perceive a great resemblance between him and Bacchus, both in actions and name. Some of the Mohammedan writers suppose Nimrod to have been Zohak, a Persian king of the first dynasty; others contend for his being Cay Caus, the second king of the second race; and some of the Jews say he is the same with Amraphel, the king of Shinaar, mentioned by Moses. But there is no certainty in these conjectures, nor have we any knowledge of his immediate successors.

The scripture mentions nothing as to the death of Nimrod; but authors have taken care that such an essential circumstance in his history should not be wanting. Some of the rabbins pretend he was slain by Esau, whom they make his contemporary. There is a tradition that he was killed by the fall of the tower of Babel, which was overthrown by tempestuous winds. Others say, that as he led an army against Abraham, God sent a squadron of gnats, which destroyed most of them; and particularly Nimrod, whose brain was pierced by one of those insects.

NINE, the last of the radical numbers or characters; from the combination of which any definite number, however large, may be produced. "It is

observed

Nimrod,
Nine.

Nineveh. observed by arithmeticians (says Hume), that the products of 9 compose always either 9 or some lesser products of 9, if you add together all the characters of which any of the former products is composed: thus of 18, 27, 36, which are products of 9, you make 9, by adding 1 to 8, 2 to 7, 3 to 6. Thus 369 is a product also of 9; and if you add 3, 6, and 9, you make 18, a lesser product of 9." See *Hume's Dialogues on Nat. Relig.* p. 167, 168, &c. 2d edit.

NINEVEH (anc. geog.), the capital city of Assyria, founded by Ashur the son of Shem (Gen. x. 11.); or, as others read the text, by Nimrod the son of Cush.

However this be, yet it must be owned, that Nineveh was one of the most ancient, the most famous, the most potent, and largest cities of the world. It is very difficult exactly to assign the time of its foundation; but it cannot be long after the building of Babel. It was situated upon the banks of the Tigris; and in the time of the prophet Jonas, who was sent thither under Jeroboam II. king of Israel, and, as Calmet thinks, under the reign of Pul, father of Sardanapalus, king of Assyria, Nineveh was a very great city, its circuit being three days journey (Jonah iii. 3.) Diodorus Siculus, who has given us the dimensions of it, says it was 480 fathoms in circumference, or 47 miles; and that it was surrounded with lofty walls and towers; the former being 200 feet in height, and so very broad that three chariots might drive on them abreast; and the latter 200 feet in height, and 1500 in number; and Strabo allows it to have been much greater than Babylon. Diodorus Siculus was, however, certainly mistaken, or rather his transcribers, as the authors of the Universal History think, in placing Nineveh on the Euphrates, since all historians as well as geographers who speak of that city, tell us in express terms that it stood on the Tigris. At the time of Jonah's mission thither, it was so populous, that it was reckoned to contain more than six score thousand persons, who could not distinguish their right hand from their left (Jon. iv. 11.), which is generally explained of young children that had not yet attained to the use of reason; so that upon this principle it is computed that the inhabitants of Nineveh were then above 600,000 persons.

Nineveh was taken by Arbaces and Belshazzar, in the year of the world 3257, under the reign of Sardanapalus, in the time of Ahas king of Judah, and about the time of the foundation of Rome. It was taken a second time by Astyages and Nabopolassar from Chynaladanus king of Assyria in the year 3378. After

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this time, Nineveh no more recovered its former splendor. It was so entirely ruined in the time of Lucianus Samosatensis, who lived under the emperor Adrian, that no footsteps of it could be found, nor so much as the place where it stood. However, it was rebuilt under the Persians, and destroyed again by the Saracens about the seventh age.

Modern travellers say (A), that the ruins of ancient Nineveh may still be seen on the eastern banks of the Tigris, opposite to the city Mosul or Mousul: (See MOUSUL). Profane historians tell us, that Ninus first founded Nineveh; but the scripture assures us, that it was Ashur or Nimrod.

The sacred authors make frequent mention of this city; and Nahum and Zephaniah foretold its ruin in a very particular and pathetic manner.

NINIA, or NINIAN, commonly called *St Ninian*, a holy man among the ancient Britons. He resided at or near a place called by Ptolemy *Lucoptibia*, and by Bede *Candida Rasa*; but the English and Scotch called it *Whitberne*. We mention him, because he is said to have been the first who converted the Scots and Picts to the Christian faith; which he did during the reign of Theodosius the Younger. Bede informs us, that he built a church dedicated to St Martin, in a style unknown to the Britons of that time; and adds, that during his time the Saxons held this province (*Galloway* now *Galloway*), and that, as in consequence of the labours of this saint the converts to Christianity increased, an Episcopal see was established there. Dr Henry, considering that "few or none of the writings of the most ancient fathers of the British church are now extant, and since little being said of them by their cotemporaries, we can know little of their personal history and of the extent of their erudition," gives a short account of some of them. Of St Ninian he says, "he was a Briton of noble birth and excellent genius. After he had received as good an education at home as his own country could afford, he travelled for his further improvement, and spent several years at Rome, which was then the chief seat of learning as well as of empire. From thence he returned into Britain, and spent his life in preaching the gospel in the most uncultivated parts of it, with equal zeal and success."

There is a small town called *St Ninian* about a mile south of Stirling. Its church had been occupied by the rebels in 1745 as a powder-magazine; who on their return blew it up in such haste, as to destroy some of their own people and about fifteen spectators.

NING-PO-FOU, called by the Europeans *Liampo*, is

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(A) This assertion, however, is far from seeming probable; for every trace of it seems to have so totally disappeared, even so early as A. D. 627, that the vacant space afforded a spacious field for the celebrated battle between the Emperor Heraclius and the Persians. There are few things in ancient history which have more puzzled the learned world, than to determine the spot where this city stood. Mr Ives informs us, that some have imagined it stood near Jonah's tomb; others, however, place it at another place, some hours journey up the Tigris. These different opinions, however, seem perfectly reconcileable; for it appears at least probable, that ancient Nineveh took in the whole of the ground which lies between these two ruined places. Mr Ives adds, that "what confirms this conjecture is, that much of this ground is now hilly, owing no doubt to the rubbish of the ancient buildings. There is one mount of 200 or 300 yards square, which stands some yards north-east of Jonah's tomb, whereon it is likely a fortification once stood. It seems to have been made by nature, or perhaps both by nature and art, for such an use."

Ninon
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Niob.

an excellent port, on the eastern coast of China, opposite to Japan. Eighteen or twenty leagues from this place is an island called *Tcheou-chan*, where the English first landed on their arrival at China.

The silks manufactured at Ning-po are much esteemed in foreign countries, especially in Japan, where the Chinese exchange them for copper, gold, and silver. This city has four others under its jurisdiction, besides a great number of fortresses.

NINON LENCLOS, a celebrated lady in the court of France, was of a noble family, and born at Paris in the year 1615; but rendered herself famous by her wit and gallantries. Her mother was a lady of exemplary piety; but her father early inspired her with the love of pleasure. Having lost her parents at 14 years of age, and finding herself mistress of her own actions, she resolved never to marry: she had an income of 10,000 livres a year; and, according to the lessons she had received from her father, drew up a plan of life and gallantry, which she pursued till her death. Never delicate with respect to the number, but always in the choice, of her pleasures, she sacrificed nothing to interest; but loved only while her taste for it continued; and had among her admirers the greatest lords of the court. But though she was light in her amours, she had many virtues.—She was constant in her friendships, faithful to what are called the *laws of honour*, of strict veracity, disinterested, and more particularly remarkable for the exactest probity. Women of the most respectable characters were proud of the honour of having her for their friend; at her house was an assemblage of every thing most agreeable in the city and the court; and mothers were extremely desirous of sending their sons to that school of politeness and good taste, that they might learn sentiments of honour and probity, and those other virtues that render men amiable in society. But the illustrious Madame de Sevigné with great justness remarks in her letters, that this school was dangerous to religion and the Christian virtues; because Ninon Lenclos made use of seducing maxims, capable of depriving the mind of those invaluable treasures. Ninon was esteemed beautiful even in old age; and is said to have inspired violent passions at 80. She died at Paris in 1705. This lady had several children; one of whom, named *Chevalier de Villiers*, occasioned much discourse by the tragical manner in which he ended his life. He became in love with Ninon, without knowing that she was his mother; and when he discovered the secret of his birth, stabbed himself in a fit of despair. There have been published the pretended Letters of Ninon Lenclos to the marquis de Sevigné.

NINTH, in music. See INTERVAL.

NINUS, the first king of the Assyrians, was, it is said, the son of Belus. It is added, that he enlarged Nineveh and Babylon; conquered Zoroaster king of the Bactrians; married Semiramis of Ascalon; subdued almost all Asia; and died after a glorious reign of 52 years, about 1150 B. C.; but all these facts are uncertain. See SEMIRAMIS.

NIO, an island of the Archipelago, between Naxi

to the north, Armago to the east, Santerino to the south, and Sikino to the west, and is about 35 miles in circumference. It is remarkable for nothing but Homer's tomb, which they pretend is in this island; for they affirm that he died here in his passage from Samos to Athens. The island is well cultivated, and not so steep as the other islands, and the wheat which it produces is excellent; but oil and wood are scarce. It is subject to the Turks. E. Long. 25. 53. N. Lat. 36. 35.

NIOBE, (fab. hist.) according to the fictions of the poets was the daughter of Tantalus, and wife of Amphion king of Thebes; by whom she had seven sons and as many daughters. Having become so proud of her fertility and high birth, as to prefer herself before Latona, and to slight the sacrifices offered up by the Theban matrons to that goddess, Apollo and Diana, the children of Latona, resented this contempt. The former slew the male children and the latter the female; upon which Niobe was struck dumb with grief, and remained without sensation. Cicero is of opinion, that on this account the poets feigned her to be turned into stone.

The story of Niobe is beautifully related in the sixth book of the *Metamorphoses* of Ovid. That poet thus describes her transformation into stone.

Widow'd and childless, lamentable state!

A doleful sight, among the dead she sat;

Harden'd with woes, a statue of despair,

To ev'ry breath of wind unmov'd her hair;

Her cheek still redd'ning, but its colour dead,

Faded her eyes, and set within her head.

No more her pliant tongue its motion keeps,

But stands congeal'd within her frozen lips.

Stagnate and dull, within her purple veins,

Its current stopp'd, the lifeless blood remains.

Her feet their usual offices refuses,

Her arms and neck their graceful gestures lose:

Action and life from every part are gone,

And ev'n her entrails turn to solid stone.

Yet still she weeps; and whirl'd by stormy winds,

Borne thro' the air, her native country finds;

There fix'd, she stands upon a bleak hill;

There yet her marble cheeks eternal tears distil.

Niobe in this statue is represented as in an ecstasy of grief for the loss of her offspring, and about to be converted into stone herself. She appears as if deprived of all sensation by the excess of her sorrow, and incapable either of shedding tears or of uttering any lamentations, as has been remarked by Cicero in the third book of his *Tusculan Questions*. With her right hand she clasps one of her little daughters, who throws herself into her bosom; which attitude equally shows the ardent affection of the mother, and expresses that natural confidence which children have in the protection of a parent. The whole is executed in such a wonderful manner, that this, with the other statues of her children, is reckoned by Pliny among the most beautiful works of antiquity: but he doubts to whom of the Grecian artists he ought to ascribe the honour of them (4). We have no certain information at what period

Niobe.

(4) Par hæsitatio in templo Apollinis sossiani, Niobem cum liberis morientem, Scopas an Praxiteles fecerit.

Niobe.
||
Nisan.

riod this celebrated work was transported from Greece to Rome, nor do we know where it was first erected. Flaminius Vacca only says, that all these statues were found in his time not far from the gate of St John, and that they were afterwards placed by the Grand Duke Ferdinand in the gardens of the Villa de Medici near Rome.—An ingenious and entertaining traveller (Dr Moore), speaking of the statue of Niobe, says, "The author of Niobe has had the judgment not to exhibit all the distress which he might have placed in her countenance. This consummate artist was afraid of disturbing her features too much, knowing full well that the point where he was to expect most sympathy was there, where distress co-operated with beauty, and where *our pity met our love*. Had he sought it one step farther in *expression*, he had lost it.

In the following epigram this statue is ascribed to Praxiteles:

Εκ ζωης μὲν Θεοὶ θεὸν σκεπασάντων. Ἐκ δὲ λίθου
Ζωνὴν Πραξιτέλης ἐμπαλὶν εἰργασάτο.

While for my childrens fate I vainly mourn'd,
The angry gods to massy stone me turn'd;
Praxiteles a nobler feat has done,
He made me live again from being stone.

The author of this epigram, which is to be found in the 4th book of the *Anthologia*, is unknown. Scalliger the father, in his *Farrago Epigrammatum*, p. 172. ascribes it to Callimachus, but this appears to be only conjecture. Cœlius Calpurnius has made a happy translation of it into Latin.

*Vivam olim in lapidem verterunt numina; sed me
Praxiteles vivam reddidit ex lapide.*

And perhaps the following French version of it will appear no less happy:

*De vive que j'étois, les Dieux
M'ont changée en pierre massive;
Praxitele a fait beaucoup mieux,
De pierre il m'a su rendre vive.*

NIPHON, the largest of the Japan islands, being 600 miles long and 100 broad. See JAPAN.

NIPPERS, in the manege, are four teeth in the fore-part of a horse's mouth, two in the upper, and two in the lower jaw. A horse puts them forth between the second and third year.

NIPPLES, in anatomy. See there, n° 112.

NIPPLE-WORT, in botany. See LAPSANA.

NISAN, a month of the Hebrews, answering to our March, and which sometimes takes from February or April, according to the course of the moon. It was the first month of the sacred year, at the coming out of Egypt (Exod. xii. 2), and it was the seventh month of the civil year. By Moses it is called Abib. The name Nisan is only since the time of Ezra, and the return from the captivity of Babylon.

On the first day of this month the Jews fasted for the death of the children of Aaron (Lev. x. 1, 2, 3.) On the tenth day was celebrated a fast for the death of Miriam the sister of Moses; and every one provided himself with a lamb for the passover. On this day the Israelites passed over Jordan under the conduct of Joshua (iv. 19.) On the fourteenth day in the evening they sacrificed the paschal lamb; and

the day following, being the fifteenth, was held the solemn passover (Exod. xii. 18. &c.) The sixteenth they offered the sheaf of the ears of barley as the first-fruits of the harvest of that year (Levit. xxiii. 9. &c.) The twenty-first was the octave of the passover, which was solemnized with particular ceremonies. The twenty-sixth the Jews fasted in memory of the death of Joshua. On this day they began their prayers to obtain the rains of the spring. On the twenty-ninth they called to mind the fall of the walls of Jericho.

NISI PRIUS, in law, a judicial writ which lies in cases where the jury being impannelled and returned before the justices of the bank, one of the parties requests to have such a writ for the ease of the country, in order that the trial may come before the justices in the same county on their coming thither. The purport of a writ of *nisi prius* is, that the sheriff is thereby commanded to bring to Westminster the men impannelled, at a certain day, before the justices, "*nisi prius justiciarii domini regis ad assisas capiendas venerint.*"

NISIBIS (anc. geog.), a city both very ancient, very noble, and of very considerable strength, situated in a district called *Mygdonia*, in the north of Mesopotamia, towards the Tigris, from which it is distant two days journey. Some ascribe its origin to Nimrod, and suppose it to be the *Achad* of Moses. The Macedonians called it *Antiochia of Mygdonia* (Plutarch); situated at the foot of mount Masius (Strabo). It was the Roman bulwark against the Parthians and Persians. It sustained three memorable sieges against the power of Sapor, A. D. 338, 346, and 350; but the emperor Jovianus, by an ignominious peace, delivered it up to the Persians, A. D. 363.—A colony called *Septimia Nesibitana*.—Another *Nisibis*, of Aria, (Ptolemy), near the lake Arias.

Mr Ives, who passed through this place in 1758, tells us, that "it looked pretty at a distance, being seated on a considerable eminence, at the foot of which runs a river, formerly called the *Mygdonius*, with a stone bridge of eleven arches built over it. Just by the river, at the foot of the hill, or hills (for the town is seated on two), begins the ruins of a once more flourishing place, which reach quite up to the present town. From every part of this place the most delightful prospects would appear, were the soil but properly cultivated and planted; but instead of those extensive woods of fruit trees, which Rawolf speaks of as growing near the town, not above thirty or forty straggling trees of any kind can be perceived; and instead of that great extent of arable land on which he dwells so much, a very inconsiderable number of acres are now remaining. The town itself is despicable, the streets extremely narrow, and the houses, even those which are of stone, are mean. It suffered grievously by the famine of 1757, losing almost all its inhabitants either by death or desertion. The streets presented many miserable objects, who greedily devoured rinds of cucumbers, and every other refuse article of food thrown out into the highway. Here the price of bread had risen near 4000 per cent. within the last 14 years.

NISMES, an ancient, large, and flourishing town of France, in Languedoc, with a bishop's see, and an academy. It has such a number of manufactures of

Nis
||
Nismes.

Nismes
||
Nithsdale.

cloth of gold and silk, and of stuffs formerly known by the name of serge of Nismes, as exceeds that of all the rest of the province. There are several monuments of antiquity, of which the amphitheatre is the principal, built by the Romans. The *maison carrée*, or the square-house, is a piece of architecture of the Corinthian order, and one of the finest in the world. The temple of Diana is in part gone to ruin. It was taken by the English in 1417. The inhabitants were all Calvinists; but Louis XIV. demolished their church in 1685, and built a castle to keep them in awe. It is seated in a delightful plain, abounding in wine, oil, game, and cattle. It contains a great number of venerable relicks of Roman antiquity and grandeur, which it is not our business to describe, though it is chiefly remarkable for these and its delightful situation. It owed much to M. de Beedelievre, a late bishop there: "A prelate (says Mr Townsend) equally distinguished for wisdom, benevolence, and piety; who, by his wisdom and beneficence, in the space of 45 years much more than doubled the number of inhabitants of Nismes; for, having found only 20,000, he had the happiness before his death of seeing 50,000 rise up to call him blessed." Mr Wraxal says, "it is an ill-built place, containing in itself nothing extraordinary or remarkable." A hundred fables are related concerning its origin, which is carried into times anterior by many centuries to the Roman conquests. It probably does not occupy at present the fourth part of the ground on which it formerly stood. E. Long. 4. 26. N. Lat. 43. 50.

NISROCH, a god of the Assyrians. Sennacherib was killed by two of his sons while he was paying his adoration to his god Nisroch in his temple (2 Kings xix. 37.) It is not known who this god Nisroch was. The septuagint calls him Mesrach, Josephus calls him Araskes. The Hebrew of Tobit published by Munster calls him Dagon. The Jews have a strange notion concerning this deity, and fancy him to have been a plank of Noah's ark. Some think the word signifies a dove; and others understand by it an eagle, which has given occasion to an opinion, that Jupiter Belus, from whom the Assyrian kings pretended to be derived, was worshipped by them under the form of an eagle, and called Nisroch. Our poet Milton gives this name to one of the rebel angels.

— In the assembly next up stood
Nisroch, of principalities the prince.

Par. Lost, B. VI. v. 447.

NISSOLIA, in botany: A genus of the decandria order, belonging to the diadelphia class of plants; and in the natural method ranking under the 32d order, *Papilionaceæ*. The calyx is quinque-dentate; the capsule monospermous, and terminated by a ligulated wing.

NITHSDALE, **NITHSDALE**, or *Niddisdale*, a division of Dumfriesshire in Scotland, lying to the westward of Annandale. It is a large and mountainous tract, deriving its name from the river Nid, which issues from a lake called *Loch-cure*, runs by the towns of Sanquhar, Morton, and Drumlanrig, and discharges itself into the Solway Frith. This country was formerly shaded with noble forests, which are now almost destroyed; of that, at present, nothing can be more naked, wild,

and savage. Yet the bowels of the earth yields lead, and, as is said, silver and gold: the mountains are covered with sheep and black cattle; and here are still some considerable remains of the ancient woods, particularly that of Holywood, three miles from Dumfries, noted for an handsome church, built out of the ruins of an ancient abbey; and also for being the birth-place of the famous astrologer, hence called *Joannes de Sacro Bosco*. Mr Pennant calls it a beautiful vale, improved in appearance by the bold curvatures of the meandering stream, and for some space, he says, it is adorned with groves and gentlemen's seats.

NITOCRIS, the mother of Belshazzar (whose father was Evil Merodach and his grandfather Nebuchadnezzar), was a woman of extraordinary abilities: she took the burden of all public affairs upon herself; and, while her son followed his pleasures, did all that could be done by human prudence to sustain the tottering empire. She perfected the works which Nebuchadnezzar had begun for the defence of Babylon; raised strong fortifications on the side of the river, and caused a wonderful vault to be made under it, leading from the old palace to the new, 12 feet high and 15 wide. She likewise built a bridge across the Euphrates, and accomplished several other works, which were afterwards ascribed to Nebuchadnezzar. Philostrates, in describing this bridge, tells us, that it was built by a queen, who was a native of Media; whence we may conclude this illustrious queen to have been by birth a Mede. Nitocris is said to have placed her tomb over one of the most remarkable gates of the city, with an inscription to the following effect:

If any king of Babylon after me shall be in distress for money, he may open this sepulchre, and take out as much as may serve him; but if he be in no real necessity, let him forbear, or he shall have cause to repent of his presumption.

This monument and inscription are said to have remained untouched till the reign of Darius, who, considering the gate was useless, no man caring to pass under a dead body, and being invited by the hopes of an immense treasure, broke it open: but, instead of what he sought, is said to have found nothing but a corpse; and another inscription, to the following effect:

Hadst thou not been most insatiably avaricious and greedy of the most sordid gain, thou wouldst never have violated the abode of the dead.

NITRARIA, in botany: A genus of the monogynia order, belonging to the dodecandria class of plants; and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous, with the petals arched at the top; the calyx quinquefid; the stamina 15; the fruit a monospermous plum.

NITRE, or **SALTPETRE**. See **CHEMISTRY**, n° 740.

Calcareous NITRE. Ibid. n° 747.

Cubic NITRE. Ibid. n° 741.

NITROUS, any thing impregnated with nitre.

NITROUS Air. See **AEROLOGY** and **EUDIOMETER**.

NIVELLE, a town of the Austrian Netherlands, in the province of Brabant, remarkable for its abbey of Canonesses. Here is a manufacture of cambrics, and the town enjoys great privileges. The abbey just mentioned

Nitocris.
||
Nivelles.

Nivelle mentioned is inhabited by young ladies of the first quality, who are not confined therein as in nunneries, but may go out and marry whenever they see convenient, or a proper match offers. E. Long. 4. 20. N. Lat. 50. 46.

NIVELLE de la Chauffée (Peter Claude), a comic poet, born in Paris; acquired great reputation by inventing a new kind of entertainment, which was called the *Weeping Comedy*. Instead of imitating Aristophanes, Terence, Moliere, and the other celebrated comic poets who had preceded him; and instead of exciting laughter by painting the different ridiculous characters, giving strokes of humour and absurdities in conduct; he applied himself to represent the weaknesses of the heart, and to touch and soften it. In this manner he wrote five comedies: 1. *La fausse Antipathie*. 2. *Le Préjugé à la Mode*; this piece met with great success. 3. *Mélanide*. 4. *Amour pour Amour*; and, 5. *L'Ecole des Meres*. He was received into the French academy in 1736; and died at Paris in 1754, at 63 years of age. He also wrote a tragedy, intitled, *Maximianus*; and an Epistle to Clio, an ingenious didactic poem.

NIVERNONIS, an inland province of France, with the title of a *duchy*, lying on the west side of Burgundy, and between it Bourbonnois and Barri. It is pretty fertile in wine, fruit, and corn; except the part called *Morvant*, which is a mountainous country, and barren. There is a great deal of wood, and several iron-mines; as also mines of pit-coal, which serves to work their forges. This province is watered by a great number of rivers; of which the Allier, the Loire, and the Yonne, are navigable. Nevers is the capital city.

NIWEGAL, in Pembrokeshire, South Wales, a small village and beach on the coast, remarkable only for the discovery of an immense quantity of the stumps of trees appearing below low-water-mark, after and during a storm in the year 1590, notwithstanding the country all round it is entirely barren of wood.

NIXAPA, a rich and considerable town in New Spain, with a rich convent of Dominicans. The country about it abounds in cochineal, indigo, and sugar. E. Long. 97. 25. N. Lat. 15. 20.

NIZAM (says Gibbons), one of the most illustrious ministers of the east, was honoured by the caliph as an oracle of religion and science; he was trusted by the sultan as the faithful vicegerent of his power and justice. After an administration of 30 years, the fame of the vizir, his wealth, and even his services, were transformed into crimes. He was overthrown by the insidious arts of a woman and a rival; and his fall was hastened by a rash declaration, that his cap and ink-horn, the badges of his office, were connected by the divine decree with the throne and diadem of the sultan. At the age of 93 years, the venerable statesman was dismissed by his master, accused by his enemies, and murdered by a fanatic: the last words of Nizam attested his innocence, and the remainder of Malek's life was short and inglorious.

NO, (Jeremiah, Ezekiel), **NO-AMMON**, (Nahum); a considerable city of Egypt, thought to be the name of an idol which agrees with Jupiter-Ammon. The Septuagint translate the name in Ezekiel, *Diospolis*, "the city of Jupiter." Bochart takes it to be *Thebes* of

Egypt; which, according to Strabo and Ptolemy, was called *Diospolis*. Jerome, after the Chaldee paraphrast Jonathan, supposes it to be Alexandria, named by way of anticipation; or an ancient city of that name is supposed to have stood on the spot where Alexandria was built.

No-Man's-Land, a space between the after part of the belfrey and the fore-part of a ship's boat, when the said boat is stowed upon the booms, as in a deep-waisted vessel. These booms are laid from the fore-castle nearly to the quarter-deck, where their after-ends are usually sustained by a frame called the *gallows*, which consists of two strong posts, about six feet high, with a cross piece reaching from one to the other, athwart ships, and serving to support the ends of those booms, masts, and yards, which lie in reserve to supply the place of others carried away, &c. The space called *No-Man's-land* is used to contain any blocks, ropes, tackles, &c. which may be necessary on the fore-castle. It probably derives this name from its situation, as being neither on the starboard nor larboard side of the ship, nor on the waist or fore-castle; but, being situated in the middle, partakes equally of all those places.

NOAH, or **NOE**, the son of Lamech, was born in the year of the world 1056. Amidst the general corruption into which all mankind were fallen at this time, Noah alone was found to be just and perfect in his generation, walking with God. (Gen. vi. 9.) This extraordinary person having therefore found favour in the eyes of the Lord, and God seeing that all flesh had corrupted their ways, told Noah, that he was resolved to destroy mankind from the face of the earth, by a flood of waters; and not them alone, but all the beasts of the earth, and every creeping thing, as well as the fowls of the air. (*Id. ib. 7.*) The Lord therefore directed Noah, as a means of preserving him and his family (for he had three sons, Shem, Ham, and Japheth, who were all married before the flood), to build an ark or vessel, of a certain form and size fitted to that end, and which might besides accommodate such numbers of animals of all sorts, that were liable to perish in the flood, as would be sufficient to preserve the several species, and again replenish the earth; together with all necessary provisions for them; all which Noah performed, as may be seen more particularly under the article **ARK**.

In the year of the world 1656, and in the 600th year of his age, Noah, by God's appointment, entered the ark, together with his wife, his three sons, their wives, and all the animals which God caused to come to Noah; and being all entered, and the door of the ark being shut upon the outside, the waters of the deluge began to fall upon the earth, and increased in such a manner, that they were fifteen cubits above the tops of the highest mountains, and continued thus upon the earth for 150 days; so that whatever had life upon the earth, or in the air, was destroyed, except such as were with Noah in the ark. But the Lord remembering Noah, sent a wind upon the earth, which caused the waters to subside; so that upon the seventeenth day of the seventh month the ark rested on the mountains of Ararat: and Noah having uncovered the roof of the ark, and observing the earth was dry, he received orders from the Lord to come out of it, with all the animals.

**No-Man's
Land,
Noah.**

Noah.

mals that were therein; and this he did in the six hundred and first year of his age, on the 27th day of the second month. But the history of the deluge is more circumstantially related already under the article DELUGE.

Then he offered as a burnt sacrifice to the Lord one of all the pure animals that were in the ark; and the Lord accepted his sacrifice, and said to him, that he would no more pour out his curse upon the whole earth, nor any more destroy all the animals as he had now done. He gave Noah power over all the brute creation, and permitted him to eat of them, as of the herbs and fruits of the earth; except only the blood, the use of which God did not allow him. He bid him increase and multiply, made a covenant with him, and God engaged himself to send no more an universal deluge upon the earth; and as a memorial of his promise, he set his bow in the clouds, to be as a pledge of the covenant he made with Noah. (Gen. ix.)

Noah being an husbandman, began now to cultivate the vine; and having made wine and drank thereof, he unwarily made himself drunk, and fell asleep in his tent, and happened to uncover himself in an indecent posture. Ham, the father of Canaan, having observed him in this condition, made himself sport with him, and acquainted his two brothers with it, who were without. But they, instead of making it a matter of sport, turned away from it, and going backwards they covered their father's nakedness, by throwing a mantle over him. Noah awaking, and knowing what Ham had done, said, that Canaan the son of Ham should be accursed, that he should be a slave of slaves in respect of his brethren. It is thought he had a mind to spare the person of his son Ham, for fear the curse might light upon the other children of Ham, who had no part in this action. He cursed Canaan by a spirit of prophecy, because the Canaanites his descendants were after this to be rooted out by the Israelites. Noah added, Let the Lord, the God of Shem, be blessed, and let Canaan be the servant of Shem. And he was so in effect, in the person of the Canaanites subdued by the Hebrews. Lastly, Noah said, Let God extend the possession of Japheth; let Japheth dwell in the tents of Shem, and let Canaan be his servant. This prophecy had its accomplishment, when the Grecians, and afterwards the Romans, being descended from Japheth, made a conquest of Asia, which was the portion of Shem.

But Noah lived yet after the deluge three hundred and fifty years; and the whole time of his life having been nine hundred and fifty years, he died in the year of the world 2006. He left three sons, Shem, Ham, and Japheth, of which mention is made under their several names; and according to the common opinion, he divided the whole world amongst them, in order to repeople it. To Shem he gave Asia, to Ham Africa, and Europe to Japheth. Some will have it, that besides these three sons, he had several others. The spurious Berosus gives him thirty, called Titans, from the name of their mother Titzæ. They pretend that the Teutons or Germans are derived from a son of Noah called Thuifcon. The false Methodius also makes mention of Jonithus or Jonicus, a pretended son of Noah.

St Peter calls Noah a preacher of righteousness (2 Peter ii. 5.), because before the deluge he was in-

cessantly preaching and declaring to men, not only by his discourses, but by his unblameable life, and by the building of the ark, in which he was employed six score years, that the wrath of God was ready to pour upon them. But his preaching had no effect, since, when the deluge came, it found mankind plunged in their former enormities. (Mat. xxiv. 37.)

Several learned men have observed, that the Hea-then confounded Saturn, Deucalion, Ogyges, the god Cælus or Ouranus, Janus, Protheus, Promotheus, &c. with Noah. The wife of Noah is called Noriah by the Gnostics; and the fable of Deucalion and his wife Pyrrha is manifestly invented from the history of Noah.

The Rabbins pretend, that God gave Noah and his sons (all who are not of the chosen race of Abraham they call Noachidæ) certain general precepts, which contain, according to them, the natural right which is common to all men indifferently, and the observation of which alone will be sufficient to save them. After the law of Moses, the Hebrews would not suffer any stranger to dwell in their country, unless he would conform to the precepts of the Noachidæ. In war they put to death, without quarter, all that were ignorant of them. These precepts are seven in number.

The *first* directs, that obedience be paid to judges, magistrates, and princes.

By the *second*, the worship of false gods, superstition, and sacrilege, are absolutely forbidden.

The *third* forbids cursing the name of God, blasphemies, and false oaths.

The *fourth* forbids all incestuous and unlawful conjunctions, as sodomy, bestiality, and crimes against nature.

The *fifth* forbids the effusion of blood of all sorts of animals, murder, wounds, and mutilations.

The *sixth* forbids thefts, cheats, lying, &c.

The *seventh* forbids to eat the parts of an animal still alive, as was practised by some pagans.

To these the Rabbins have added some others: but what inclines us to doubt the antiquity of these precepts is, that no mention is made of them in scripture, or in the writings of Josephus or Philo; and that none of the ancient fathers knew any thing of them.

NOB, a sacerdotal city of the tribe of Benjamin or Ephraim. St Jerom says, that in his time it was entirely destroyed, and that the ruins of it might be seen not far from Diospolis. When David was drove away by Saul, he went to Nob, and asking the high-priest Abimelech for some provisions and arms, the priest gave him the shew-bread which had been lately taken off the holy table, and the sword of Goliath. Saul being informed of this by Doeg, caused all the priests of Nob to be slain, and the city to be destroyed. 1 Sam. xxi. xxii.

NOBAH, a city beyond Jordan. It took the name of Nobah from an Israelite of this name who had made a conquest of it, (Numb. xxxii. 42.) Gideon pursued the Midianites as far as this city, (Judg. viii. 2.) Eusebius says, that there is a desolate place of this name about eight miles from Heshbon towards the south. But this could not be the Nobah now mentioned, because it was much farther to the north.

NOBILIARY, in literary history, a book containing

Noah
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Nobiliary.

Nobility. taining the history of the noble families of a nation or province: such are Chorier's Nobiliary of Dauphine, and Caumartin's Nobiliary of Provence. The Germans are said to be particularly careful of their Nobiliaries, in order to keep up the dignity of their families.

NOBILITY in general signifies dignity, grandeur, or greatness; more particularly, it signifies antiquity of family, joined with riches: in the common acceptance of the word, it means that quality or dignity which raises a man above the rank of a peasant or a commoner.

At a time when the public mind is so much agitated on this subject, or subjects nearly allied to it, perhaps the less that is said on it the better. We should therefore (as far as concerns the question about its expediency in civil life, or the contrary) most cheerfully pass it over in silence, did we not esteem it our duty to give our readers at least some idea of it, and were it not our business to lay before them a few of those arguments which of late have been so copiously retailed both for and against this illustrious order of civil society: leaving them, however, that liberty which every man unquestionably ought to be allowed, of judging for themselves as they shall see most proper.

Whether that equality of rank and condition which has of late been so loudly contended for would be more agreeable to the order of nature, or more conducive to the happiness and prosperity of mankind, may indeed be made a question; but it is a question, we apprehend, which cannot receive different answers from men capable of reflecting without prejudice and partiality. A state of perfect equality can subsist only among beings possessing equal talents and equal virtues; but such beings are not men. Were all mankind under the constant influence of the laws of virtue, a distinction of ranks would be unnecessary; but in that case civil government itself would likewise be unnecessary, because men would have attained all that perfection to which it is the object of civil government as well as of religion to guide them: every man then would be a law unto himself. But whilst, in so many breasts, the selfish passions predominate over those which are social, violence must be restrained by authority; and there can be no authority without a distinction of ranks, such as may influence the public opinion.

It is well observed by Hume, that government is founded only on opinion; and that this opinion is of two kinds, opinion of interest, and opinion of right. When a people are persuaded that it is their interest to support the government under which they live, that government must be very stable. But among the worthless and unthinking part of the community, this persuasion has seldom place. All men, however, have a notion of rights—of a right to property and a right to power; and when the majority of a nation considers a certain order of men as having a right to that eminence in which they are placed, this opinion, call it prejudice or what we will, contributes much to the peace and happiness of civil society. There are many, however, who think otherwise, and imagine that “the society in which the greatest equality prevails must always be the most secure. These men conceive it to be the

business of a good government to distribute as equally as possible those blessings which bounteous nature offers to all.” It may readily be allowed that this reasoning is conclusive; but the great question returns, “How far can equality prevail in a society which is secure? and what is possible to be done in the equal distribution of the blessings of Nature?” Till these questions be answered, we gain nothing by declaiming on the rights and equality of men; and the answers which have sometimes been given to them suppose a degree of perfection in human nature, which, if it were real, would make all civil institutions useless, as well as the reveries of those reformers. The conduct of the democratic states of Pagan antiquity, together with the oppressive anarchy and shameful violences which we have seen and still see in a neighbouring kingdom, will be considered by many as a full and satisfactory answer, deduced from experience, to all the schemes of the visionary theorist: such facts at least render the abolition of the order of nobility a matter of more importance, and of infinitely greater difficulty, than those who plead for it are disposed to allow.

It is an opinion not uncommon, and at least plausible, that the nobility of a well regulated state is the best security against monarchical despotism or lawless usurpation on the one hand, and the confusion of democratic insolence on the other. Self-interest is the most powerful principle in the human breast; and it is obviously the interest of such men to preserve that balance of power in society upon which the very existence of their order depends. Corrupted as the present age confessedly is, a very recent instance could be given, in which the British House of Peers rescued at once the sovereign and the people from the threatened tyranny of a factious junto. As it is our business, however, to exhibit all opinions of any celebrity, we shall lay before our readers a short extract from Dulaure's Critical History of the French Nobility, which contains, in few but forcible words, some of the common arguments against this distinction of ranks.

“Nobility (says he), a distinction equally impolitic and immoral, and worthy of the times of ignorance and of rapine, which gave it birth, is a violation of the rights of that part of the nation that is deprived of it; and as equality becomes a stimulus towards distinction, so on the other hand this is the radical vice of a government and the source of a variety of evils. It is almost impossible that there should be any uncommon instances of virtue in a state, when recompences belong exclusively to a certain class of society, and when it costs them no more to obtain these than the trouble of being born. Amongst this list of privileged persons, virtues, talents, and genius, must of course be much less frequent than in the other classes, since, without the possession of any of these qualities, they who belong to it are still honoured and rewarded. Those who profit by this absurd subversion of principles, and those who lose by this unjust distribution of favours, which seem to have grown into a right, cannot have any other than false, immoral, and pernicious ideas concerning merit.”

A perfect equality, however, in rank and fortune has seldom been contended for, except by the most ignorant enthusiasts. It is indeed doubtful whether

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Nobility. it could possibly exist. The more moderate and rational reformers have acknowledged, that as these differences have always existed in some way or other, so, from the infinite variety of talents and attainments in the world, we have reason to expect they will exist in every form of government and among every people. The question, therefore, is reduced to this: Whether the present mode of distinction, or any other which could be instituted in its stead, be upon the whole the best? That the present is not perfect, or wholly without faults, few will be sanguine enough to contradict: and a wise man in the sober hour of philosophical reflection will scarce presume to assert, that any other scheme which human ingenuity can plan would be wholly without imperfection, or altogether free from error. The case is, the errors of our own system are present, and on this account we see and feel them with peculiar force: the other plan we look forward to, perhaps in too sanguine a manner, and we probably forget, in the delusive heat of imagination, that if distinction depended entirely on merit, we should scarce find a society of men so honest, or so able, as always to reward it according to its deserts; or if this were possible, as perhaps in the nature of things it is not, such is the self-partiality of the generality of men, that few would think he were dealt justly by if he were not promoted as well as his neighbour; and it is clearly impossible to promote every one. For such reasons then, and many more which our limits oblige us to omit, many think (and we are inclined to think with them), that it is safer to remain as we are, as we know the evils that attend our situation, and are still able to bear them, rather than to hazard a change, which, with some benefits, might also perhaps increase the troubles, and destroy many of the pleasures, of social life.

Perhaps it may not be amiss to lay before our readers the following observations from that most judicious commentator on the laws of England, Mr Justice Blackstone, on this important subject.

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"The distinction of rank and honours (says he) is necessary in every well-governed state, in order to reward such as are eminent for their services to the public, in a manner the most desirable to individuals, and yet without burden to the community; exciting thereby an ambitious, yet laudable ardour, and generous emulation, in others. And emulation, or virtuous ambition, is a spring of action which, however dangerous or invidious in a mere republic or under a despotic sway, will certainly be attended with good effects under a free monarchy; where, without destroying its existence, its excesses may be continually restrained by that superior power from which all honour is derived. Such a spirit, when nationally diffused, gives life and vigour to the community; it sets all the wheels of government in motion, which, under a wise regulator, may be directed to any beneficial purpose; and thereby every individual may be made subservient to the public good, while he principally means to promote his own particular views. A body of nobility is also more peculiarly necessary in our mixed and compounded constitution, in order to support the rights of both the crown and the people, by forming a barrier to withstand the encroachments of both. It creates and preserves that gradual scale of

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dignity, which proceeds from the peasant to the prince; rising like a pyramid from a broad foundation, and diminishing to a point as it rises. It is this ascending and contracting proportion that adds stability to any government; for when the departure is sudden from one extreme to another, we may pronounce that state to be precarious. The nobility, therefore, are the pillars, which are reared from among the people, more immediately to support the throne; and, if that falls, they must also be buried under its ruins. Accordingly, when in the last century the commons had determined to extirpate monarchy, they also voted the house of lords to be useless and dangerous. And since titles of nobility are thus expedient in the state, it is also expedient that their owners should form an independent and separate branch of the legislature. If they were confounded with the mass of the people, and like them had only a vote in electing representatives, their privileges would soon be borne down and overwhelmed by the popular torrent, which would effectually level all distinctions. It is therefore highly necessary that the body of nobles should have a distinct assembly, distinct deliberations, and distinct powers from the commons."—These remarks, at a time like the present, deserve our serious attention; nor do we suppose our readers will be displeased, if we add the following observations on the subject from a periodical publication of long standing and very considerable merit.

"Birth and nobility are a stronger obligation to virtue than is laid upon meaner persons. A vicious or dishonourable nobleman is in effect perjured; for his honour is his oath. *Gent. Mag. Vol. xii.*

"Under the patriarchal scheme, and at the first setting out of the tribes, the heads of families had their particular escutcheons, and their genealogies recorded with the utmost exactness: Even the Ancient of Days confirmed this; he often put his people in mind of the glory and virtues of their forefathers; and hath set a precedent for attainders, by visiting the third and fourth generation.

"It is a vulgar error to suppose, that his blessed Son chose his followers out of the meanest of the people, because mechanics; for this was part of the education of every Jewish nobleman: Two of the number, being his kinsmen, were of the royal house of David; one was a Roman gentleman, and another of the royal family of Syria; and for the rest, he had the same right of creation as his father and his vicegerents, of advancing the poor to honour, and of exalting the lowly and meek.

"The ancient Greeks and Romans paid great regard to nobility; but when the levelling principle obtained, and the people shared power and honour, those states soon dwindled and came to ruin. And in present Rome, great respect is paid to the renowned families of Colonna and Cæsarini. In Venice, the notion of nobility is carried so high as to become inconsistent with a republican scheme. The Spaniards pay more regard to their old nobles than to their old Christians; and the French are but little behind them. What was said of the duke of Montmorency by Henry IV. "That he was a better gentleman than himself," was, perhaps, the reason why the last heir of so illustrious a family was cut off, to make the house of

Bourbon

Nobility. Bourbon the first in France.—The Welsh, Irish, and Polanders, are remarkable for their attachments to blood and pedigree.

“It is for the sake of the meanest of our people, that the high value and regard for quality should be kept up; for they are best governed by those who seem formed for power: the robe of authority fits easy upon them, and submission is as much our choice as our duty; but upstarts prove the worst of tyrants.

“The ancient legislators, who studied human nature, thought it adviseable, for the better government of states, that the people should be divided into the noble and the common. They judged it for the universal good of mankind, that the valiant and the wise should be separated from the rest, and appointed for council and command.

“To this I take it that the institution of nobility is owing in all countries; even those nations which we are pleased to call *savage*, distinguish the wise and the valiant, obey them as counsellors, and commanders which is placing them in the rank of nobles.

“Some, I know, look upon the institution of nobility to be one of the grossest impositions upon the common sense of mankind; they confine it indeed to hereditary nobility; they allow, that those who have done the commonwealth any signal service should be distinguished with honours, but it seems an absurdity to them that a man should be born a legislator, as if wisdom or a knowledge of government run in the blood. But if they would consider how strong the love of posterity is planted in human nature, they must allow that nothing can be a stronger motive to great and worthy actions, than the notion that a man's posterity will reap the honour and profit of his labours. Besides, we are to suppose that men born to honours and a high fortune may be bred up in generous sentiments, and formed for the station they are to fill; that they must be strangers to those vicious falsehoods and corruptions which necessity first, and then habit, puts men upon practising, whose lives are spent in pursuit of their fortunes. I will own, notwithstanding all these advantages, that many of them are like rocks whose heads are in the clouds, but are so barren that they are quite incapable of producing any thing; but in general, were their minds only upon a level with those of other men, we should expect better fruit from them.

“As authority is founded in opinion, all wise commonwealths have been extremely jealous in keeping up the honour of their nobility. Wherever they become base, effeminate, cowardly, or servile, their authority sinks, they fall into contempt; then the people begin to consider them as useless to government, and look upon their privileges as a grievance to society, and perhaps they think how to get rid of them, as happened in the commonwealth of Florence, where, after the expulsion of the duke of Athens, a petty tyrant of that city, many of the nobility having behaved servilely to him, and insolently to the people, were degraded from the senate and the magistracy, and rendered incapable of holding any employment in the commonwealth.

“Father Paul, the Venetian, says, that you must either keep your nobility free from taint, or have no

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Nobility. nobility at all: That the high employments of the commonwealth should be bestowed amongst the most ancient families, unless where a person should distinguish himself by some signal service to the state. Such a man would think himself sufficiently rewarded by the honour of being put upon a foot with the ancient nobility; and the nobility would be pleased to find that no commoner, except some of great reputation and merit, was to hold any of the employments usually possessed by their body. If the person so preferred should not be rich enough to support the dignity of the office, the state may give him a pension, but by no means should employments be made lucrative; which not only exhaust and weaken the commonwealth, but wherever the high employments are sought for profit, the nobility lose their generous sentiments, and it is a means of introducing corruption amongst them.”

The origin of nobility in Europe is by some referred to the Goths; who, after they had seized a part of Europe, rewarded their captains with titles of honour, to distinguish them from the common people. We shall only in this place further consider the manner in which in our own country they may be created, and the incidents attending them; referring for a fuller account of their origin in Europe to the articles REVOLUTION, and SOCIETY (*Civil*).

1. The right of peerage seems to have been originally territorial; that is, annexed to lands, honours, castles, manors, and the like; the proprietors and possessors of which were (in right of those estates) allowed to be peers of the realm, and were summoned to parliament to do suit and service to their sovereign; and, when the land was alienated, the dignity passed with it as appendant. Thus in England the bishops still sit in the house of lords in right of succession to certain ancient baronies annexed, or supposed to be annexed, to their episcopal lands; and thus in 11 Henry VI. the possession of the castle of Arundel was adjudged to confer an earldom on its possessor. But afterwards, when ALIENATIONS grew to be frequent, the dignity of peerage was confined to the lineage of the party ennobled, and instead of territorial became personal. Actual proof of a tenure by barony became no longer necessary to constitute a lord of parliament; but the record of the writ of summons to him or his ancestors was admitted as a sufficient evidence of the tenure.

Peers of Great Britain are now created either by writ or by patent: for those who claim by prescription must suppose either a writ or patent made to their ancestors; though by length of time it is lost. The creation by writ, or the king's letter, is a summons to attend the house of peers, by the style and title of that barony which the king is pleased to confer: that by patent is a royal grant to a subject of any dignity and degree of peerage. The creation by writ is the more ancient way; but a man is not ennobled thereby, unless he actually take his seat in the house of lords; and some are of opinion that there must be at least two writs of summons, and a sitting in two distinct parliaments, to evidence an hereditary barony: and therefore the most usual, because the surest, way is to grant the dignity by patent, which endures to a man and his

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heirs according to the limitation thereof, though he never himself makes use of it. Yet it is frequent to call up the eldest son of a peer to the house of lords by writ of summons, in the name of his father's barony: because in that case there is no danger of his childrens losing the nobility in case he never takes his seat; for they will succeed to their grandfather. Creation by writ has also one advantage over that by patent; for a person created by writ holds the dignity to him and his heirs, without any words to that purport in the writ; but in letters patent there must be words to direct the inheritance, else the dignity endures only to the grantee for life. For a man or woman may be created noble for their own lives, and the dignity not descend to their heirs at all, or descend only to some particular heirs: as where a peerage is limited to a man and the heirs male of his body by Elizabeth his present lady, and not to such heirs by any former or future wife.

2. Let us next take a view of a few of the principal incidents attending the nobility,—exclusive of their capacity as members of parliament, and as hereditary counsellors of the crown, for both which we refer to the articles LORDS and PARLIAMENT. And first we must observe, that in criminal cases a nobleman shall be tried by his peers. The great are always obnoxious to popular envy: were they to be judged by the people, they might be in danger from the prejudice of their judges; and would moreover be deprived of the privilege of the meanest subjects, that of being tried by their equals, which is secured to all the realm by magna charta, c. 29. It is said, that this does not extend to bishops; who, though they are lords of parliament, and sit there by virtue of their baronies which they hold *jure ecclesiæ*, yet are not ennobled in blood, and consequently not peers with the nobility. As to peeresses, no provision was made for their trial when accused of treason or felony, till after Eleanor duchess of Gloucester, wife to the lord protector, had been accused of treason, and found guilty of witchcraft, in an ecclesiastical synod, through the intrigues of Cardinal Beaufort. This very extraordinary trial gave occasion to a special statute, 20 Hen. VI. c. 9. which enacts, that peeresses, either in their own right or by marriage, shall be tried before the same judicature as peers of the realm. If a woman, noble in her own right, marries a commoner, she still remains noble, and shall be tried by her peers: but if she be only noble by marriage, then by a second marriage with a commoner she loses her dignity; for as by marriage it is gained, by marriage it is also lost. Yet if a duchess-dowager marries a baron, she continues a duchess still; for all the nobility are *pares*, and therefore it is no degradation. A peer or peeress (either in her own right or by marriage) cannot be arrested in civil cases: and they have also many peculiar privileges annexed to their peerage in the course of judicial proceedings. A peer sitting in judgment, gives not his verdict upon oath, like an ordinary jurymen, but upon his honour; he answers also to bills in chancery upon his honour, and not upon his oath: but, when he is examined as a witness either in civil or criminal cases, he must be sworn; for the respect which the law shows to the honour of a peer does not extend so far as to overturn a settled maxim, that *in judicio*

non creditur nisi juratus. The honour of peers is however so highly tendered by the law, that it is much more penal to spread false reports of them, and certain other great officers of the realm, than of other men: scandal against them being called by the peculiar name of *scandalum magnatum*, and subjected to peculiar punishment by divers ancient statutes.

A peer cannot lose his nobility but by death or attainder; though there was an instance, in the reign of Edward IV. of the degradation of George Nevile duke of Bedford by act of parliament, on account of his poverty, which rendered him unable to support his dignity. But this is a singular instance: which serves at the same time, by having happened, to show the power of parliament; and, by having happened but once, to show how tender the parliament hath been in exerting so high a power. It hath been said indeed, that if a baron wastes his estate, so that he is not able to support the degree, the king may degrade him: but it is expressly held by later authorities, that a peer cannot be degraded but by act of parliament.

Anton. Matthæus observes, that nobility, among the Romans, was a quite different thing from what it is among us. The nobles, among the Romans, were either those raised to the magistrature, or descended from magistrates: there was no such thing as nobility by patent.

Bartoli says, that doctors, after they have held a professor's chair in an university for 20 years, become noble; and are intitled to all the rights of counts.

But this claim is not admitted at court, &c. though Bartoli's sentiments be backed with those of several other authors, particularly Chassanæus in his *Consuetudin. Burgundiæ*; Boyer sur la *Coutume de Berry*; Faber *C. de Dig. Def. 9.* &c. which last, however, restrains Bartoli's rule to doctors in law, and princes physicians.

By an edict of the French king in 1669, it is declared, that trade shall not derogate from nobility, provided the person do not sell by retail.

In Bretagne, by ancient custom, a nobleman loses nothing by trading even in retail: but he reassumes all his rights as soon as he ceases traffic, his nobility having slept all the time.

In Germany, a woman, not noble by birth, doth not become, *v. gr.* a countess or baroness by marrying a count or baron: a lady of the higher degree indeed becomes a princess by marrying a prince; but this doth not hold of a lady of the lower nobility.

On the coast of Malabar, children are only capable of being noble by the mother's side; it being allowed them to take as many husbands as they please, and to quit them whenever they think good.

NOBLE, *Nobilis*, a person who has a privilege which raises him above a commoner or peasant, either by birth, by office, or by patent from his prince. The word comes from the Latin *nobilis*; formed from the ancient *noscibilis*, "distinguishable, remarkable."

In England, the word *noble* is of a narrower import than in other countries; being confined to persons above the degree of knights; whereas, abroad, it comprehends not only knights, but what we simply call gentlemen. The nobles of England are also called *pares regni*, as being *nobilitatis pares*, though *gradu impares*.

The Venetian *noblese* is famous: it is in this that the

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Nobles, Nocera. the sovereignty of the state resides. It is divided into three classes. The first only comprehends 24 families. The second includes the descendants of all those who were entered in the golden book, in 1289, and destined to govern the state, which then began to be aristocratic. The third consists of such as have bought the dignity of noble Venetians. This last class is only admitted to the inferior employs; the two former to all indifferently. The title of *noble Venetians* is sometimes also given to foreign kings, princes, &c.

NOBLES, among the Romans, were such as had the *jus imaginum*, or the right of using the pictures or statues of their ancestors; a right which was allowed only to those whose ancestors had borne some *curule* office, that is, had been *curule ædile*, *censor*, *prætor*, or *consul*. For a long time, none but the *Patricii* were the *nobiles*, because no person but of that superior rank could bear any *curule* office; hence in Livy, Salust, &c. *nobilitas* is used to signify the Patrician order, and so opposed to *plebs*. To make the true meaning of *nobiles* still more clear, let it be observed, that the Roman people were divided into *nobiles*, *novi*, and *ignobiles*. *Nobiles* were they who had the pictures, &c. of their ancestors; *novi* were such as had only their own; *ignobiles* were such as had neither. See *Jus Imaginis*.

The Roman nobility, by way of distinction, wore an half moon upon their shoes, especially those of Patrician rank.

The Grecian nobility were called *Ευαγγελισται*, as being descended from these old heroic ancestors so famous in history. Such were the *Præxiægidae*, *Etrobutide*, *Alcæonide*, &c. all which had many privileges annexed to their quality; amongst which was this, that they wore grasshoppers in their hair as a badge of nobility.

NOBLE, a money of account containing six shillings and eight pence.

The noble was anciently a real coin struck in the reign of Edward III. and then called the *penny of gold*; but it was afterwards called a *rose-noble*, from its being stamped with a rose: it was current at 6s. 8d.

NOCERA, a town in Italy, in the dominions of the king of Naples and Sicily, or, as he is more commonly called, the king of the Two Sicilies. It is an episcopal city, but might with greater propriety be styled a cluster of villages: its several parts being extended along the foot of the mountains, form the Città Sotana, or low town; and the bishop's palace, together with some convents embowered in cypress groves, cover the peak of a single hill in a very picturesque manner, and compose the Città Soprana.

Nocera (A), it is reported, contains near 30,000 inhabitants; they are dispersed in forty patches of habitation. Their houses are constructed of two kinds of stone: the common walls are built with yellow tufa dug out of the hills that lie about a mile to the east of the town; which stone seems unquestionably to have been formed by a consolidation of substances thrown out of Vesuvius; because, on opening these quarries, the workmen have frequently discovered tombs, vases,

and coins locked up in the body of the stony stratum. The cases of their doors and windows are made of a black stone drawn from the hill of Fiano, two miles to the north; it lies eight feet below the surface, in a bed or vein 140 feet thick, resting upon a base of sand. This seems evidently to be a stream of lava congealed.

Nocera is a place of very considerable antiquity: in the 13th century it was called de Pagani, to distinguish it from a city in Umbria of a similar name; this addition was in allusion to a colony of Saracens which Frederick of Suabia brought from Sicily, and settled here, that they might be out of the way of their dangerous connections with Africa: hence Nocera has often been confounded with Lucera by the negligent or ignorant chroniclers of the succeeding ages. The most remarkable event that occurs in its history is the siege of its castle, A. D. 1384. E. Long. 12. 55. N. Lat. 43. 2.

Terra NOCERIANA, *Earth of Nocera*, in the materia medica, a species of bole remarkably heavy, of a greyish-white colour, of an insipid taste, and generally with some particles in it which grit between the teeth. It is much esteemed by the Italians as a remedy for venomous bites, and in fevers; but, excepting as an absorbent and astringent, no dependence is to be had on it.

NOCTAMBULI, **NOCTAMBULONES**, or *Night-walkers*; a term of equal import with *somnambuli*, applied to persons who have a habit of rising and walking about in their sleep. The word is a compound of the Latin *nox*, "night," and *ambulo*, "I walk."

Schenkius, Horstius, Clauderus, and Hildanus, who have wrote of sleep, give us divers unhappy histories of such noctambuli. When the disease is moderate, the persons affected with it only repeat the actions of the day on getting out of bed, and go quietly to the places they frequented at other times; but those who have it in the most violent degree, go up to dangerous places, and do things which would terrify them to think of when they are awake. These are by some called *lunatic* night-walkers, because fits are observed to return with the most frequency and violence at the changes of the moon.—For the cure some recommend purging and a cooling regimen: others are of opinion that the best method is to place a vessel of water at the patient's bedside in such a manner that he will naturally step into it when he gets out of bed; or if that should fail, a person should sit up to watch and beat him every time it happens. See **SLEEP-WALKERS**, or **SOMNAMBULI**.

NOCTILUCA, a species of phosphorus, so called because it shines in the dark without any light being thrown upon it: such is the phosphorus made of urine.

NOCTURNAL, something relating to the night, in contradistinction to diurnal.

NOCTURNAL, *Nocturlabium*, an instrument chiefly used at sea, to take the altitude or depression of some stars about the pole, in order to find the latitude and hour of the night.

Some nocturnals are hemispheres, or planispheres, M 2 on

(A) Anciently, Nuceria Alphenata, a word of unknown etymology. It was a Roman colony, and had its mint. Num. Nucerin.

1. Caput virile imberbe—Equus stans capite reflexo inter crura. A... IN...

Nocturnal
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on the plane of the equinoctial. Those commonly in use among seamen are two; the one adapted to the polar star, and the first of the guards of the Little Bear; the other to the pole star, and the pointers of the Great Bear.

This instrument consists of two circular plates, applied to each other. The greater, which has a handle to hold the instrument, is about $2\frac{1}{2}$ inches diameter, and is divided into twelve parts, agreeing to the twelve months; and each month subdivided into every fifth day; and so as that the middle of the handle corresponds to that day of the year wherein the star here regarded has the same right ascension with the sun. If the instrument be fitted for two stars, the handle is made moveable. The upper left circle is divided into twenty-four equal parts for the twenty-four hours of the day, and each hour subdivided into quarters. These twenty-four hours are noted by twenty-four teeth to be told in the night. Those at the hour 12 are distinguished by their length. In the centre of the two circular plates is adjusted a long index, moveable upon the upper plate; and the three pieces, viz. the two circles and index, are joined by a rivet which is pierced through the centre with a hole, through which the star is to be observed.

Plate
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To use the nocturnal, turn the upper plate till the long tooth, marked 12, be against the day of the month on the under plate; then, bringing the instrument near the eye, suspend it by the handle with the plane nearly parallel to the equinoctial; and viewing the pole star through the whole of the centre, turn the index about, till, by the edge coming from the centre, you see the bright star or guard of the Little Bear, (if the instrument be fitted to that star): then that tooth of the upper circle, under the edge of the index, is at the hour of the night on the edge of the hour circle: which may be known without a light, by counting the teeth from the longest, which is for the hour 12.

NOD, or the land of Nod. It was to this country that Cain withdrew after his fratricide, (Gen. iv. 16.) The septuagint, as well as Josephus, read *Naid* instead of *Nod*, and have taken it for the name of a place. It is not easily known what country this was, unless perhaps it was the country of Nyse or Nysea, towards Hyrcania. St Jerom and the Chaldee interpreters have taken the word Nod in the sense of an appellation, for *vagabond* or *fugitive*; "He dwelt a fugitive in the land." But the Hebrew reads, "He dwelt in the land of Nod." (Gen. iv. 16.)

NODAB, a country bordering upon Iturea and Idumæa, but now unknown. We read in the Chronicles, that the tribe of Reuben, assisted by those of Gad and Manasseh, had a war against the Hagarites, the Jeturites, and the people of Nephish and of Nodab, in which the Israelites had the advantage. 1 Chr. v. 19. But the time and the other particulars of this war are unknown.

NODATED HYPERBOLA, a name given by Sir Isaac Newton to a kind of hyperbola, which, by turning round, decussates or crosses itself.

NODDY. See STERNA.

NODE, a tumour arising on the bones, and usually proceeding from some venereal cause; being much the same with what is otherwise called *exosto sis*.

NODES, in astronomy, the two points where the orbit of a planet intersects the ecliptic.

Such are the two points C and D; of which the node C, where the planet ascends northward above the plane of the ecliptic, is called the *ascending node*, or the *dragon's head*, and is marked thus Ω . The other node D, where the planet descends to the south, is called the *descending node*, or the *dragon's tail*, marked thus ϑ .

The line CD, wherein the two circles CEDF and CGDH intersect, is called the *line of nodes*. It appears from observation, that the line of the nodes of all the planets constantly changes its place, and shifts its situation from east to west, contrary to the order of the signs; and that the line of the moon's nodes, by a retrograde motion, finishes its circulation in the compass of 19 years; after which time, either of the nodes having receded from any point of the ecliptic, returns to the same again; and when the moon is in the node, she is also seen in the ecliptic. If the line of nodes were immoveable, that is, if it had no other motion than that whereby it is carried round the sun, it would always look to the same point of the ecliptic, or would keep parallel to itself, as the axis of the earth does.

From what hath been said, it is evident, that the moon can never be observed precisely in the ecliptic, but twice in every period; that is, when she enters the nodes. When she is at her greatest distance from the nodes, viz. in the points E, F, she is said to be in her limits.

The moon must be in or near one of the nodes, when there is an eclipse of the sun or moon.

To make the foregoing account of the motion of the moon's nodes still clearer, let the plane of n° 2. *ibid.* represent that of the ecliptic, S the sun, T the centre of the earth, L the moon in her orbit *DN dn*. *Nn* is the line of the nodes passing between the quadrature Q and the moon's place L, in her last quarter. Let now LP, or any part LS, represent the excess of the sun's action at T; and this being resolved into the force LR, perpendicular to the plane of the moon's orbit, and PR parallel to it, it is the former only that has any effect to alter the position of the orbit, and in this it is wholly exerted. Its effect is twofold: 1. It diminishes its inclination by a motion which we may conceive as performed round the diameter Dd, to which LT is perpendicular. 2. Being compounded with the moon's tangential motion at L, it gives it an intermediate direction Lt, through which and the centre a plane being drawn, must meet the ecliptic nearer the conjunction C than before.

NODUS, or node, in dialling, a certain point or pole in the gnomon of a dial, by the shadow or light whereof either the hour of the day in dials without furniture, or the parallels of the sun's declination, and his place in the ecliptic, &c. in dials with furniture, are shown. See DIALLING.

NOEOMAGUS LEXUVIORUM, (Ptol.); thought to be the *Civitas Lexoviorum* of the lower age. Now Lisieux, a city in Normandy.—Another of the *Tricassini*; a town of Gallia Narbonensis; thought to be S. Pol de Trois Châteaux, six miles to the west of Nyons in Dauphiné.

NOETIANS, in church-history, Christian heretics in

Nodes
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Noetians.
Plate
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n° 1.

Nola

Nollet.

Nollet.

in the third century, followers of Noetius, a philosopher of Ephesus, who pretended that he was another Moses sent by God, and that his brother was a new Aaron. His heresy consisted in affirming that there was but one person in the Godhead; and that the Word and the Holy Spirit were but external denominations given to God in consequence of different operations: that, as Creator, he is called *Father*; as Incarnate, *Son*; and as descending on the apostles, *Holy Ghost*.

NOLA, a very ancient city, formerly populous and strong, situated in a plain to the north-east of Vesuvius in Campania, said to be built by the Chalcidians, (Justin, Silius Italicus); according to others, by the Tuscans. At this place Hannibal met with the first check by Marcellus. Vespasian added the appellation *Augusta Colonia*, (Frontinus). At this place, or in its neighbourhood, Augustus is said to have expired. It is also said that bells were first invented there in the beginning of the 5th century; hence their Latin names *Nole* or *Campanæ*. It retains its old name to this day, but it hath vastly fallen short of its ancient splendor. A town of the kingdom of Naples. E. Long. 15. N. Lat. 41. 9.

NOLANA, in botany: A genus of the monogynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 41st order, *Asperifolia*. The corolla is campanulated; the style situated betwixt the germens; the seeds are bilocular, and resemble berries.

NOLLE PROSEQUI, is where a plaintiff in an action does not declare in a reasonable time; in which case it is usual for the defendant's attorney to enter a rule for the plaintiff to declare, after which a *non prof.* may be entered. A *nolle prosequi* is esteemed a voluntary confession, that the plaintiff has no cause of action: and therefore if a plaintiff enters his *nolle prosequi*, he shall be amerced: and if an informer cause the same to be entered, the defendant shall have costs.

NOLLET (Jean Antoine), a deacon, licentiate in theology, preceptor to the *Enfants de France* for physics and natural history, regius professor of physics in the college of Navarre, member of the academy of sciences at Paris, of the royal society of London, of the institution of Bologna, and of the academy of sciences of Erfort; was born at Pimbré, in the diocese of Noyon, on the 17th of November 1700, of respectable but not wealthy parents. To make up the want of riches, they determined to give their son a good education. They sent him to the college of Clermont in Beauvoisis, and afterwards to Beauvais, there to finish his introductory studies. The progress which he made in the different classes, determined them to send him to study philosophy at Paris. Thenceforward they intended him for the clerical order; and they considered the strictness and purity of his morals, together with his unwearied application to study, as sufficient proofs of his vocation. The young Nollet yielded without reluctance to the wishes of his parents. As soon as he was capable of showing an inclination for any thing, he had discovered a taste for physics; but this was not become his ruling passion; he therefore sacrificed it to the study of scholastic divinity, to which he wholly dedicated himself during his time of probation in 1728. No sooner had he been invested with the deaconship, than he solicited and obtained a

licence to preach. This new occupation, however, did not make him entirely lose sight of those studies which had first engaged his attention. They insensibly began to occupy a greater portion of his time, which was now more equally divided between theology and the sciences. The latter, however, prevailed; and thenceforth he entered into the study of physics with an ardour which was only increased by that kind of privation to which he had been long subject. He was received into the society of arts, established at Paris under the patronage of the late count de Clermont. In 1730, the Abbé Nollet was engaged in a work conjointly with Reamur and du Fay of the academy of sciences. In 1734, he went to London in company with M. M. du Fay, du Hamel, and de Jussieu. His merit procured him a place in the royal society without any solicitation. Two years after, he went to Holland, where he formed an intimate connection with Desaguliers, Gravesande, and Muschenbroeck. On his return to Paris, he resumed the course of experimental physics which he had begun in 1735, and which he continued till 1760. These courses of physics first suggested the idea of particular courses in other branches of science, such as in chemistry, anatomy, natural history, &c. In 1738, the count de Maurepas prevailed on the cardinal Fleury to establish a public class for experimental physics; and the Abbé Nollet was appointed the first professor. In the beginning of the year 1739, he was admitted a member of the royal academy of sciences; and in the month of April following, the king of Sardinia intending to establish a professorship of physics at Turin, invited the Abbé Nollet into his dominions. From thence he travelled into Italy. In 1744, he was honoured with an invitation to Versailles, to instruct the dauphin in experimental philosophy; the king and royal family were often present at his lectures. The qualities as well of his understanding as of his heart gained him the esteem and confidence of his pupil. Going one day in state to Paris, he caused intimation to be made that he was to dine at the Thuilleries. M. Nollet having gone thither to pay his court, the dauphin no sooner perceived him, than he had the goodness to say, "Binet has the advantage of me, he has been at your house." Till the period of his death, this prince showed marks of the strongest attachment and favour for this ingenious philosopher. He would have wished that he had been a little more attentive to the improvement of his fortune. He prevailed upon him to go and pay court to a man in power, whose patronage might have been of service to him. The Abbé Nollet accordingly waited upon the placeman, and made him a present of his works. "I never read any works of that kind," said the patron coldly, and casting a look at the volumes before him. "Sir (replied the Abbé), will you allow them to remain in your anti-chamber? There perhaps there may be found men of genius who will read them with pleasure." In the month of April 1749, he made a grand tour into Italy, being sent thither for the purpose of making observations. At Turin, Venice, and Bologna, the Abbé Nollet appeared as a deputy from the philosophers of the rest of Europe. During his short stay in Italy, the wonders of electricity were not the only object of his

researches;

Nollet
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Nombre.

researches; every part of physics, the arts, agriculture, &c. came equally under his notice. Upon his return through Turin, the king of Sardinia, always truly sensible of his merit, offered him the order of Saint Maurice, which he did not think proper to accept without his sovereign's permission. In 1753 the king instituted a class of experimental philosophy in the royal college of Navarre, and appointed the Abbé Nollet professor. In 1757, he received from the king a brevet appointing him preceptor in physics and natural history to the *Enfants de France*. In the month of August, the same year, he was appointed professor of experimental philosophy in the school of Artillery, at that time established at la Fere. In the month of November following, he was admitted as a pensionary of the royal academy of sciences. M. de Cremillo, director-general of artillery and fortification, having founded a class of experimental philosophy at Mezieres in 1761, the Abbé Nollet was appointed professor. This celebrated and laborious philosopher, who has rendered the most important services to physics by the discoveries with which he has enriched every branch of this science, but particularly electricity, died at Paris on the 25th of April 1770, aged 70; much regretted by the literary world, and by his friends, of whom his gentle character and beneficent heart had procured him a great number. He often retired from the gay and splendid societies of Paris, to give assistance to his relations, who were by no means in affluent circumstances. His works are, 1. Several papers inserted in the memoirs of the academy of sciences; among which one on the Hearing of Fishes is particularly valuable. 2. *Leçons de Physique Experimentale*, 6 vols. 12mo; a book well composed, and uniting pleasure with instruction. 3. *Recueil de Lettres sur l'Electricité*, 3 vols. 12mo. 1753. 4. *Essai sur l'Electricité des corps*, 1 vol. 12mo. 5. *Recherches sur les causes particulieres des Phenomènes Electriques*, one vol. 12mo. 6. *L'Andes experiences*, 3 vols. 12mo. with figures, 1770.

NOMADES, a name given, in antiquity, to several nations whose whole occupation was to feed and tend their flocks; and who had no fixed place of abode, but were constantly shifting, according to the conveniences of pasturage.—The word comes from the Greek *νομα*, *pasco*, "I feed."

The most celebrated among the Nomades were those of Africa, who inhabited between Africa, properly so called, to the east, and Mauritania to the west. They are also called *Numidæ*, or *Numidians*.—Sallust says, they were a colony of Persians brought into Africa with Hercules.

The Nomades of Asia inhabited the coasts of the Caspian Sea.—The Nomades of Scythia were the inhabitants of Little Tartary; who still retain the ancient manner of living.

NOMARCHA, in antiquity, the governor or commander of a nome, or nomos.—Egypt was anciently divided into several regions or quarters, called *nomes*, from the Greek *νομος*, taken in the sense of a division; and the officer who had the administration of each *nome* or *nomos*, from the king, was called *monarcha*, from *νομος* and *αρχη* "command."

NOMBRE-DE-DIOS, a town of Mexico, in the province of Darien, a little to the eastward of Porto-Bello. It was formerly a famous place; but it is now

abandoned, on account of its unhealthy situation. W. Nombril Long. 78. 35. N. Lat. 9. 43.

NOMBRIL POINT, in heraldry, is the next below the fess-point, or the very centre of the escutcheon.

Supposing the escutcheon divided into two equal parts below the fess, the first of these divisions is the nombril, and the lower the base.

NOME, or NAME, in algebra, denotes any quantity with a sign prefixed or added to it, whereby it is connected with some other quantity, upon which the whole becomes a binomial, trinomial, or the like. See ALGEBRA.

NOMENCLATOR, in Roman antiquity, was usually a slave who attended upon persons that stood candidates for offices, and prompted or suggested to them the names of all the citizens they met, that they might court them and call them by their names, which among that people was the highest piece of civility.

NOMENCLATORS, among the botanical authors, are those who have employed their labours about settling and adjusting the right names, synonyms, and etymologies of names, in regard to the whole vegetable world.

NOMENCLATURE, NOMENCLATURA, a catalogue of several of the more usual words in any language, with their significations, compiled in order to facilitate the use of such words to those who are to learn the tongue: such are our Latin, Greek, French, &c. Nomenclatures.

The chemical nomenclature has within these few years undergone a total change: we have given a table exhibiting these new names facing page 598 of Volume IV. At that time we were not convinced of the propriety of the new theory, nor was it possible to foresee that it would so soon obtain the approbation of the literary world. True philosophy requires, however, that we should readily change our opinions when we see sufficient grounds, for to *err is human*. In consequence of Lavoisier's system being now so universally adopted, it becomes necessary for us to explain his principles at more length than was thought proper before. This we think our duty, and it therefore shall be our endeavour, in some part of the work, to introduce a sufficient analysis of this celebrated and now almost universally adopted system.

NOMENEY, a town in Germany, in the duchy of Lorraine, situated on the river Seille, 15 miles north of Nancy.

NOMINALS, or NOMINALISTS, a sect of school-philosophers, the disciples and followers of Occam, or Ockham, an English cordelier, in the 14th century. They were great dealers in words, whence they were vulgarly denominated *Word-sellers*; but had the denomination of *Nominalists*, because, in opposition to the *Realists*, they maintained, that words, and not things, were the object of dialectics.

This sect had its first rise towards the end of the 11th century, and pretended to follow Porphyry and Aristotle; but it was not till Ockham's time that they bore the name. The chief of this sect, in the 11th century, was a person called *John*, who, on account of his logical subtilty, was called the *sophist*; and his principal disciples were Robert of Paris, Roscelin of Compiègne, and Arnoul of Laon. At the beginning, the nominalists had the upper hand: but the realists, though greatly divided among themselves, were sup-

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Nominals
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ported by men of great abilities; such as Albertus Magnus, T. Aquinas, and Duns Scotus. The nominal sect became hereby into disrepute; till William Occam, in the 14th century, again revived it, and filled France and Germany with the flame of disputation. Having joined the party of the Franciscan monks, who strenuously opposed John XXII. that pope himself, and his successors after him, left no means untried to extirpate the philosophy of the nominalists, which was deemed highly prejudicial to the interests of the church: and hence it was, that, in the year 1339, the university of Paris, by a public edict, solemnly condemned and prohibited the philosophy of Occam, which was that of the nominalists. The consequence was, that the nominalists flourished more than ever. In the 15th century, the controversy was continued with more vigour and animosity than before; and the disputants were not content with using merely the force of eloquence, but had frequently recourse to more hostile and dangerous weapons; and battles were the consequence of a philosophical question, which neither side understood. In most places, however, the realists maintained a manifest superiority over the nominalists. While the famous Gerson, and the most eminent of his disciples were living, the nominalists were in high esteem and credit in the university of Paris. But upon the death of these patrons, the face of things was much changed to their disadvantage. In the year 1473, Louis XI. by the instigation of his confessor, the bishop of Avranches, issued out a severe edict against the doctrines of the nominalists, and ordered all their writings to be seized and secured, that they might not be read by the people: but the same monarch mitigated this edict the year following, and permitted some of the books of that sect to be delivered from their confinement. In the year 1481, he not only granted a full liberty to the nominalists and their writings, but also restored that philosophical sect to its former authority and lustre in the university.

The nominalists were the founders of the university of Leipsic: and there are many yet abroad who pique themselves on being nominals.

The nominals, with the Stoics, admit the formal conceptions or ideas of things, as the subject and foundation of universality: but to this they add names, which represent and signify, after the same univocal manner, and without any distinction, a great variety of single things alike in genus and species.

Whence it is that they are called *nominals*; as pretending, that to become learned, it is not enough to have just ideas of things, but it is likewise required to know the proper names of the genera and species of things, and to be able to express them clearly and precisely, without confusion or ambiguity.

NOMINATIVE, in grammar, the first CASE of NOUNS which are declinable.

The simple position, or laying down of a noun, or name, is called the *nominative case*; yet it is not so properly a case, as the matter or ground whence the other cases are to be formed, by the several changes and inflections given to this first termination. Its chief use is to be placed in discourse before all verbs, as the subject of the proposition or affirmation.

NONA, a city of Dalmatia, remarkable at present only

for its ruins, which might furnish abundant materials to gratify the curiosity of antiquaries; but indeed they are so buried by repeated devastations, to which that unhappy city has been exposed, that rarely any vestige of them appears above ground. "I went thither (says Fortis in his Travels), in hopes of finding something worthy of notice, but was disappointed. Nothing is to be seen that indicates the grandeur of the Roman times; neither are there any remains of barbarous magnificence, to put one in mind of the ages in which the kings of the Croat Slavi had their residence there. It lies on a small island, surrounded by a harbour, which in former times was capable of receiving large ships; but is now become a fetid pool by means of a little muddy river that falls into it, after a course of about six miles through the rich abandoned fields of that district. The ancient inhabitants turned this water into another channel, and made it run through the valley of Drafnich into the sea; and the remains of the bank raised by them for that purpose are still to be seen. Notwithstanding, however, the depopulation of this district, and the dreary situation of Nona in particular, the new inhabitants have not lost courage; and animated by the privileges granted to them by this most serene republic, are endeavouring to bring the population and agriculture once more into a flourishing state. Proper drains for the water would not only render that rich territory habitable, but moreover very fertile; and the brackish marsh that surrounds the walls of Nona is well calculated to supply a considerable quantity of fish, especially eels. The government generously granted the investiture to private persons, who already draw no inconsiderable advantage from the fishing; and did they but adopt better methods, they might every year salt many thousands of eels, which would greatly answer our internal commerce, and save at least a part of the money that goes out of the country for foreign salt fish. To the left of the city of Nona, the walls of some ancient ruinous buildings appear; which probably in ancient times were situated on the main land, though now surrounded by water. The sea forms a narrow channel in this place, which is easily fordable, and, at low water, the smallest boat can scarcely pass."

NONAGE, in law, generally signifies all the time a person continues under the age of 21; but, in a special sense, it is all the time that a person is under the age of 14.

NON-CAPE, a promontory on the west coast of Africa, opposite to the Canary islands. W. Long. 12. 0. N. Lat. 44. 28.

NONCONFORMISTS, those who refuse to join the established worship.

Nonconformists, in England, are of two sorts. First, such as absent themselves from divine worship in the established church through total irreligion, and attend the service of no other persuasion. These, by the stat. 1 Eliz. c. 2. 23 Eliz. c. 1. and 3 Jac. I. c. 4. forfeit one shilling to the poor every Lord's-day they so absent themselves, and 20l. to the king if they continue such default for a month together. And if they keep any inmate thus irreligiously disposed in their houses, they forfeit 10l. per month.

The second species of nonconformists are those who offend through a mistaken or perverse zeal. Such were

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Nonconformists.

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were esteemed, by the English laws enacted since the time of the Reformation, to be Papists and Protestant dissenters: both of which were supposed to be equally schismatics, in not communicating with the national church; with this difference, that the Papists divided from it upon material, though erroneous, reasons; but many of the dissenters upon matters of indifference, or, in other words, for no reason at all. "Yet certainly (says Sir William Blackstone) our ancestors were mistaken in their plans of compulsion and intolerance. The sin of schism, as such, is by no means the object of temporal coercion and punishment. If, through weakness of intellect, through misdirected piety, through perverseness and acerbity of temper, or (which is often the case) through a prospect of secular advantage in herding with a party, men quarrel with the ecclesiastical establishment, the civil magistrate has nothing to do with it; unless their tenets and practice are such as threaten ruin or disturbance to the state. He is bound indeed to protect the established church: and if this can be better effected by admitting none but its genuine members to offices of trust and emolument, he is certainly at liberty so to do; the disposal of offices being matter of favour and discretion. But this point being once secured, all persecution for diversity of opinions, however ridiculous or absurd they may be, is contrary to every principle of sound policy and civil freedom. The names and subordination of the clergy, the posture of devotion, the materials and colour of the minister's garment, the joining in a known or unknown form of prayer, and other matters of the same kind, must be left to the option of every man's private judgment.

"With regard therefore to *Protestant dissenters*, although the experience of their turbulent disposition in former times occasioned several disabilities and restrictions (which I shall not undertake to justify) to be laid upon them by abundance of statutes; yet at length the legislature, with a true spirit of magnanimity, extended that indulgence to these sectaries, which they themselves, when in power, had held to be countenancing schism, and denied to the church of England. The penalties are conditionally suspended by the statute 1 W. & M. ft. 1. c. 18. "for exempting their Majesties Protestant subjects, dissenting from the church of England, from the penalties of certain laws," commonly called the *toleration act*; which declares, that neither the laws above-mentioned, nor the statutes 1 Eliz. c. 2. § 14. 3 Jac. I. c. 4. & 5. nor any other penal laws made against Popish recusants (except the test-acts) shall extend to any dissenters, other than Papists and such as deny the Trinity: provided, 1. That they take the oaths of allegiance and supremacy, (or make a similar affirmation, being Quakers), and subscribe the declaration against Popery. 2. That they repair to some congregation certified to and registered in the court of the bishop or archdeacon, or at the county-sessions. 3. That the doors of such meeting-house shall be unlocked, unbarred, and unbolted; in default of which, the persons meeting there are still liable to all the penalties of the former acts. Dissenting teachers, in order to be exempted from the penalties of the statutes 13 & 14 Car. II. c. 4. 17 Car. II. c. 2. and 22 Car. II. c. 1. are also to subscribe the articles of religion mentioned in the statute 13 Eliz.

N° 243.

c. 12. (viz. those which only concern the confession of the true Christian faith, and the doctrine of the sacraments), with an express exception of those relating to the government and powers of the church, and to infant-baptism. And by statute 10 Ann. c. 2. this toleration is ratified and confirmed; and it is declared, that the said act shall at all times be inviolably observed for the exempting such Protestant dissenters as are thereby intended from the pains and penalties therein mentioned. Thus, though the offence of nonconformity is by no means universally abrogated, it is suspended, and ceases to exist with regard to these Protestant dissenters, during their compliance with the conditions imposed by the act of toleration: and, under these conditions, all persons, who will approve themselves no Papists or opposers of the Trinity, are left at full liberty to act as their consciences shall direct them in the matter of religious worship. And if any person shall wilfully, maliciously, or contemptuously disturb any congregation, assembled in any church or permitted meeting-house, or shall misuse any preacher or teacher there, he shall (by virtue of the same statute) be bound over to the sessions of the peace, and forfeit 20 l. But by statute 5 Geo. I. c. 4. no mayor or principal magistrate must appear at any dissenting meeting with the ensigns of his office, on pain of disability to hold that or any other office: the legislature judging it a matter of propriety, that a mode of worship, set up in opposition to the national, when allowed to be exercised in peace, should be exercised also with decency, gratitude, and humility. Neither doth the act of toleration extend to enervate those clauses of the statutes 13 & 14 Car. II. c. 4. & 17 Car. II. c. 2. which prohibit (upon pain of fine and imprisonment) all persons from teaching school, unless they be licensed by the ordinary, and subscribe a declaration of conformity to the liturgy of the church, and reverently frequent divine service *established* by the laws of this kingdom.

"As to *Papists*, what has been said of the Protestant dissenters would hold equally strong for a general toleration of them; provided their separation was founded only upon difference of opinion in religion, and their principles did not also extend to a subversion of the civil government. If once they could be brought to renounce the supremacy of the Pope, they might quietly enjoy their seven sacraments; their purgatory, and auricular confession; their worship of relics and images; nay, even their transubstantiation. But while they acknowledge a foreign power, superior to the sovereignty of the kingdom, they cannot complain if the laws of that kingdom will not treat them upon the footing of good subjects.

"The following are the laws that have been enacted against the Papists; who may be divided into three classes, persons professing Popery, Popish recusants convicted, and Popish priests. 1. Persons professing the Popish religion, besides the former penalties for not frequenting their parish-church, are disabled from taking any lands either by descent or purchase, after 18 years of age, until they renounce their errors; they must at the age of 21 register their estates before acquired, and all future conveyances and wills relating to them; they are incapable of presenting to any advowson, or granting to any other person any avoid-
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ance of the same; they may not keep or teach any school, under pain of perpetual imprisonment; and, if they willingly say or hear mass, they forfeit the one 200, the other 100 merks, and each shall suffer a year's imprisonment. Thus much for persons who, from the misfortune of family-prejudices, or otherwise, have conceived an unhappy attachment to the Romish church from their infancy, and publicly profess its errors. But if any evil industry is used to rivet these errors upon them; if any person sends another abroad to be educated in the Popish religion, or to reside in any religious house abroad for that purpose, or contributes to their maintenance when there; both the sender, the sent, and the contributor, are disabled to sue in law or equity, to be executor or administrator to any person, to take any legacy or deed of gift, and to bear any office in the realm; and shall forfeit all their goods and chattels, and likewise all their real estate for life. And where these errors are also aggravated by apostacy or perversion; where a person is reconciled to the see of Rome, or procures others to be reconciled, the offence amounts to high treason. 2. Popish recusants, convicted in a court of law of not attending the service of the church of England, are subject to the following disabilities, penalties, and forfeitures, over and above those before-mentioned. They are considered as persons excommunicated; they can hold no office or employment; they must not keep arms in their houses, but the same may be seized by the justices of the peace; they may not come within 10 miles of London, on pain of 100l; they can bring no action at law or suit in equity; they are not permitted to travel above five miles from home, unless by licence, upon pain of forfeiting all their goods; and they may not come to court, under pain of 100l. No marriage or burial of such recusant, or baptism of his child, shall be had otherwise than by the ministers of the church of England, under other severe penalties. A married woman, when recusant, shall forfeit two thirds of her dower or jointure, may not be executrix or administratrix to her husband, nor have any part of his goods; and during the coverture may be kept in prison, unless her husband redeems her, at the rate of 10l. a-month, or the third part of all his lands. And lastly, as a feme-couvert recusant may be imprisoned, so all others must, within three months after conviction, either submit and renounce their errors, or, if required so to do by four justices, must abjure and renounce the realm: and if they do not depart, or if they return without the king's licence, they shall be guilty of felony, and suffer death as felons without benefit of clergy. There is also an inferior species of recusancy, (refusing to make the declaration against Popery enjoined by statute 30 Car. II. st. 2. when tendered by the proper magistrate); which, if the party resides within ten miles of London, makes him an absolute recusant convict; or, if at a greater distance, suspends him from having any seat in parliament, keeping arms in his house, or any horse above the value of 5l. 3. Popish priests are in a still more dangerous condition. By statute 11 & 12 W. III. c. 4. Popish priests, or bishops, celebrating mass or exercising any part of their functions in England, except in the houses of ambassadors, are liable to perpetual imprisonment. And by the statute 27 Eliz. c. 2. any Popish priest, born in

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the dominions of the crown of England, who shall come over hither from beyond sea (unless driven by stress of weather and tarrying only a reasonable time), or shall be in England three days without conforming and taking the oaths, is guilty of high treason: and all persons harbouring him are guilty of felony without the benefit of clergy.

This is a short summary of the laws against the Papists; of which the president Montesquieu observes, that they are so rigorous, though not professedly of the sanguinary kind, that they do all the hurt that can possibly be done in cold blood. But in answer to this, it may be observed (what foreigners who only judge from our statute-book are not fully apprized of), that these laws are seldom exerted to their utmost rigour: and indeed, if they were, it would be very difficult to excuse them. For they are rather to be accounted for from their history, and the urgency of the times which produced them, than to be approved (upon a cool review) as a standing system of law. The restless machinations of the Jesuits during the reign of Elizabeth, the turbulence and uneasiness of the Papists under the new religious establishment, and the boldness of their hopes and wishes for the succession of the queen of Scots, obliged the parliament to counteract so dangerous a spirit by laws of a great, and then perhaps necessary, severity. The powder-treason, in the succeeding reign, struck a panic into James I. which operated in different ways: it occasioned the enacting of new laws against the Papists; but deterred him from putting them in execution. The intrigues of queen Henrietta in the reign of Charles I. the prospect of a Popish successor in that of Char. II. the assassination-plot in the reign of king William, and the avowed claim of a Popish pretender to the crown in subsequent reigns, will account for the extension of these penalties at those several periods of our history. But now that all just fears of a pretender may be said to have vanished, and the power and influence of the pope has become feeble, ridiculous, and despicable, not only in Britain, but in almost every kingdom of Europe; and as in fact the British Catholics solemnly disclaim the dangerous principles ascribed to them †; † See their the British legislature, giving way to that liberality of sentiment becoming Protestants, have lately repealed the most rigorous of the above edicts, viz. The punishment of Popish priests or Jesuits who should be found to teach or officiate in the services of that church; which acts were felony in foreigners, and high treason in the natives of this kingdom:—The forfeitures of Popish heirs, who had received their education abroad; and whose estates went to the next Protestant heir.—The power given to the son, or other relation, being a Protestant, to take possession of the father's or other relation's estate, during the life of the real proprietor:—And the debarring Papists from the power of acquiring any legal property by purchase.—In proposing the repeal of these penalties, it was observed, That, besides that some of them had now ceased to be necessary, others were at all times a disgrace to humanity. The imprisonment of a Popish priest for life, only for officiating in the services of his religion, was horrible in its nature: And although the mildness of government had hitherto softened the rigour of the law in the practice, it was to be remembered that the Roman Catholic

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loyal Address to the Throne, May 1. 1778, as inserted in the Magazines or Annual Register for that year.

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tholic priests constantly lay at the mercy of the basest and most abandoned of mankind—of common informers; for on the evidence of any of these wretches, the magisterial and judicial powers were of necessity bound to enforce all the shameful penalties of the act. Others of these penalties held out the most powerful temptations for the commission of acts of depravity, at the very thought of which our nature recoils with horror: They seemed calculated to loosen all the bands of society; to dissolve all civil, moral, and religious obligations and duties, to poison the sources of domestic felicity, and to annihilate every principle of honour. The encouragement given to children to lay their hands upon the estates of their parents, and the restriction which debars any man from the honest acquisition of property, need only to be mentioned to excite indignation in an enlightened age.

In order the better to secure the English established church against perils from non-conformists of all denominations, infidels, Turks, Jews, heretics, Papists, and sectaries, there are, however, two bulwarks erected; called the *corporation* and *test acts*: By the former of which, no person can be legally elected to any office relating to the government of any city or corporation, unless, within a twelvemonth before, he has received the sacrament of the Lord's supper according to the rites of the church of England; and he is also enjoined to take the oaths of allegiance and supremacy at the same time that he takes the oath of office: or, in default of either of these requisites, such election shall be void. The other, called the *test act*, directs all officers civil and military to take the oaths and make the declaration against transubstantiation, in any of the king's courts at Westminster, or at the quarter-sessions, within six kalendar months after their admission; and also within the same time to receive the sacrament of the Lord's Supper, according to the usage of the church of England, in some public church immediately after divine service and sermon, and to deliver into court a certificate thereof signed by the minister and church-warden, and also to prove the same by two credible witnesses; upon forfeiture of 500l. and disability to hold the said office. And of much the same nature with these is the statute 7 Jac. I. c. 2. which permits no persons to be naturalised or restored in blood, but such as undergo a like test: which test having been removed in 1753, in favour of the Jews, was the next session of parliament restored again with some precipitation.

Non-Naturals, in medicine, so called, because by their abuse they become the causes of diseases.

Physicians have divided the non-naturals into six classes, viz. the air, meats and drinks, sleep and watching, motion and rest, the passions of the mind, the retentions and excretions. See *MEDICINE*, *passim*.

Non Obstante, (*notwithstanding*), a clause frequent in statutes and letters-patent, importing a licence from the king to do a thing, which at common law might be lawfully done, but being restrained by act of parliament cannot be done without such licence.

Non Pros. See *NOLLE Prosequi*.

Non-Suit, signifies the dropping of a suit or action, or a renouncing thereof by the plaintiff or defendant; which happens most commonly upon the discovery of

some error in the plaintiff's proceedings when the cause is so far proceeded in, that the jury is ready at the bar to deliver in their verdict.

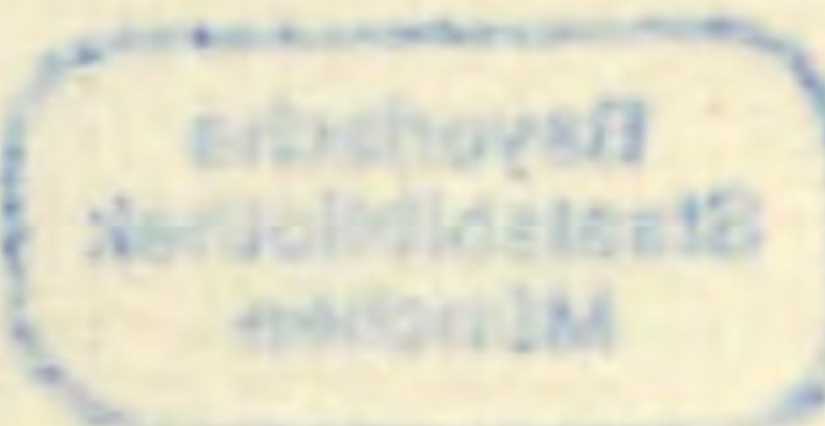
NONES, (*NONÆ*), in the Roman kalendar, the fifth day of the months January, February, April, June, August, September, November, and December; and the seventh of March, May, July, and October. March, May, July, and October, had six days in their nones; because these alone, in the ancient constitution of the year by Numa, had 31 days a-piece, the rest having only 29, and February 30; but when Cæsar reformed the year, and made other months contain 31 days, he did not allot them six days of nones.

NONJURORS, those who refused to take the oaths to government, and who were in consequence under certain incapacities, and liable to certain severe penalties. It can scarcely be said that there are any nonjurors now in the kingdom; and it is well known that all penalties have been removed both from Papists and Protestants, formerly of that denomination, as well in Scotland as in England. The members of the Episcopal church of Scotland have long been denominated Nonjurors; but perhaps they are now called so improperly, as the ground of their difference from the establishment is more on account of ecclesiastical than political principles.

NONIUS (Peter), in Spanish *Nunez*, a learned Portuguese, and one of the ablest mathematicians of the 16th century, was born at Alcacer. He was preceptor to Don Henry, king Emmanuel's son, and taught the mathematics in the university of Coimbra. He published the following works, by which he gained great reputation: 1. *De arte navigandi*. 2. *Annotationes in theorias planetarum Purbachii*; which are greatly esteemed. 3. A treatise *De Crepusculis*. 4. A treatise on algebra. It is observed in Furetiere's dictionary, that Peter Nonius, in 1530, first invented the angles of 45 degrees made in every meridian, and that he called them *rhumbs* in his language, and calculated them by spherical triangles. Nonius died in 1577, aged 80.

NONIUS, the name which was not many years ago given to the common device for subdividing the arcs of quadrants and other astronomical instruments, from the persuasion that it was invented by *Nonius* or *Nunez*, of whom some account has been given in the preceding article. The generality of astronomers of the present age, transferring the honour of the invention from *Nunez* to *Peter Vernier*, a native of Franche Comte, have called this method of division by his name. (See *VERNIER*). Mr Adams, however, in his *Geometrical and Geographical Essays*, has lately shown that Clevis the Jesuit may dispute the invention with them both. The truth seems to be, that *Nunez* started the idea, *Clevis* improved it, and *Vernier* carried it to its present state of perfection. The method of *Nunez*, described in his treatise *De Crepusculis*, printed at Lisbon 1542, consists in describing within the same quadrant 45 concentric circles, dividing the outermost into 90 equal parts, the next within into 89, the next into 88, &c. till the innermost was divided into 46 only. On a quadrant thus divided the plumb line or index must cross one or other of the circles very near a point of division; whence, by computation, the degrees

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degrees and minutes of the arch might be easily ascertained. This method is also described by Nunez in his treatise *De arte atque ratione navigandi*, where he would fain persuade himself, that it was not unknown to Ptolemy. But as the degrees are thus divided very unequally, and as it is very difficult to attain exactness in the division, especially when the numbers into which the arches are to be divided are composite (of which there are no less than nine), the method of diagonals, first published by Thomas Digges Esq; in a treatise intitled *Ala seu scale mathematica*, printed at London in 1573, and said to be invented by one Richard Chenseler, was substituted in its room. Nonius's method was, however, improved at different times and by different persons; and it must be acknowledged, that if Vernier saw either the original or any of the improvements (and there can be little doubt of his having seen them all), his merit is only that of having applied to an useful practical purpose the speculative invention of another person.

NONIUS (Marcellus), a grammarian and peripatetic philosopher, born at Tivoli, wrote a treatise, intitled *De proprietate sermonum*. This author is only valuable for his giving fragments of ancient authors that are nowhere else to be found. The above treatise was printed at Paris in 1614, with notes.

NONNIUS, or NONIUS (Lewis,) a learned physician of Antwerp in the 17th century, wrote several works which are esteemed; the principal of which are, 1. An excellent treatise intitled *Ichthyophagia, sive de Piscium esu*. 2. *Hispania*; which is of great use in understanding the ancient geography of Spain. 3. A commentary on the medals of Greece, and those of Julius Cæsar, Augustus, and Tiberius, in folio; it contains Goltzius's two words on the same subject. 4. A commentary on Goltzius's account of Greece, the islands, &c. 5. Poems, &c.

NONNUS, a Greek poet of the 5th century, and native of Panopolis in Egypt, was the author of an heroic poem in 48 books, intitled *Dionysiacorum*, and a paraphrase in verse of St John's Gospel, which may serve as a commentary upon it.

NONUPLA, in the Italian music, denotes a quick time, peculiar to jigs. This species of time is otherwise called *the measure of nine times*, which requires two falls of the hand, and one rise. There are three sorts of nonupla. 1. *Nonupla di semi-minime*, or *dupla sesquiquarta*, thus marked $\frac{3}{2}$, where nine crotchets are to be in the bar, of which four make a semi-breve in common time, *i. e.* in the down stroke six, and but three up: it is usually beat *adagio*. 2. *Nonupla di crome*, or *sesqui ottava*, marked thus $\frac{3}{4}$, wherein nine quavers make a bar instead of eight in common time, *i. e.* six down and three up: it is beat *presto*. 3. *Nonupla di semi-crome* or *super setti partiente nona*, thus distinguished $\frac{3}{8}$, in which nine semi-quavers are contained in a bar, whereof sixteen are required in common time, six down, and three up: it is ordinarily beat *prestissimo*. Beside these, there are two other species of nonupla, for which see TRIPLE.

NOOTKA-SOUND, or, as it was called by Captain Cook, *King George's Sound*, lies in N. Lat. 49. 33. W. Long. 153. 12. It is an entrance or strait to a vast inland sea on the west coast of North America, and is said to resemble the Baltic or Mediterranean in Europe. Upon the sea-coast the land is tolerably high

and level; but within the sound it rises into steep hills, which have an uniform appearance. The trees of which the woods are composed, are the Canadian pine, white cyprus, and two or three other sorts of pine. In general, the trees grow here with great vigour, and are of a large size. About the rocks and borders of the woods were seen some strawberry plants and raspberry, currant, and gooseberry bushes, all in a flourishing state. The principal animals seen here were racoons, martens, and squirrels. Birds are far from being numerous, and those that are to be seen are remarkably shy, owing perhaps to their being continually harassed by the natives, either to eat them, or to become possessed of their feathers to be worn as ornaments. The quebrantahueffos, shags, and gulls, were seen off the coast; and the two last were also frequent in the sound. Though the variety of fish is not very great, yet they are in greater quantities than birds. The principal sorts are the common herring, a silver coloured bream, and another of a brown colour. Captain Cook and Doctor King, who visited this place, consider it as an excellent shelter for ships: and in the account of a *Voyage to the Pacific Ocean*, they give some directions for sailing into it. These and other matters of that kind we shall not trouble our readers with; and perhaps the generality of them will be better pleased with the following extract from Meares's *Voyages to the North-west Coast of America*.

"The people of the Nootka nation are, in general, robust and well proportioned:—their faces are large and full, their cheeks high and prominent, with small black eyes:—their noses are broad and flat, their lips thick, and they have generally very fine teeth, and of the most brilliant whiteness.

"The manner in which the children of Nootka are treated, when young, is not more extraordinary from its strange, and, as it should appear, total inutility, as from its agreement with the customs of the Chinese and Tartars, to whom this practice gives these people a considerable resemblance. The head of the infant is bound by the mother with a kind of fillet of several folds, as low down as the eyes, in order to give it a certain form, which, at this tender age, it is capable of receiving. It might be supposed, that such a tight drawn ligature must cause considerable pain to the child; but we never observed that any of the infants, in such a state of preparation for sugar-loaf heads, suffered any visible pain or inconvenience.

"Though the custom of compressing the head in this manner gives them an unpleasant appearance, by drawing up the eye-brows, and sometimes producing the disagreeable effect of squinting, as well as of flattening the nose and distending the nostrils, they are by no means an ill looking race of people. They have also the custom, which is known to prevail in so many Indian nations, of plucking out the beard by the roots, on its first appearance; and, as it continues to sprout, to keep it down by the same practice. It is one of the domestic employments assigned to their wives, to watch this appearance of manhood, and to eradicate the hairs as they come forth; which they do in a very dexterous manner with their fingers, and without giving the least pain in the operation.—Some of them, however, though we saw but very few of this disposition, when they advance in years and become infirm, suffer their beards to grow without interruption. But, notwithstanding

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standing they have so great an aversion to the hair of their chin, that of the head is an object of their attentive vanity: it is strong, black, and glossy, grows to a considerable length, and is either tied in a kind of knot on the top of their heads, or suffered to hang down their backs in flowing negligence.

"In their exterior form they have not the symmetry or elegance which is found in many other Indian nations.—Their limbs, though stout and athletic, are crooked and ill-shaped; their skin, when cleansed of filth and ochre, is white; and we have seen some of the women, when in a state of cleanliness (which, however, was by no means a common sight, and obtained with difficulty), who not only possessed the fair complexion of Europe, but features that would have attracted notice, for their delicacy and beauty, in those parts of the world where the qualities of the human form are best understood. But these examples of beauty are by no means numerous among the women of Nootka, who are calculated rather to disgust than to charm an European beholder. Their hair, like that of the men, is black; their eyes are of the same colour; and, in exterior appearance, they are not to be immediately distinguished from the men. In their characters they are reserved and chaste; and examples of loose and immodest conduct were very rare among them. There were women at St George's Sound, whom no offers could tempt to meretricious submissions."

All reports concerning Nootka Sound agree in characterizing the inhabitants as "a very inoffensive race of people."—Inoffensive, however, as they are, a custom of a very unnatural, and we should imagine cruel, kind prevails among them: for, together with many other articles which they exposed to sale to Captain Cook's ships, they brought human skulls and hands (part of the flesh still remaining on them), which they acknowledged they had been feeding on; and some of them, we are told, had evident marks of the fire.

From hence it is too apparent, that the horrid practice of devouring their enemies exists here as well as at New Zealand and other South sea-islands: and hence, too, appears what men of even the best natural dispositions will be, if left entirely to the freedom of their own will, without law to controul or religion to instruct them. As there are but two villages of the Sound inhabited, the number of people cannot be many; perhaps they are about 2000 in all. Our limits prevent us from being so minute as we could wish to be, respecting the form of their houses and their manner of building them; of their furniture, decorations, and other things of that kind: we can therefore only refer those who wish for further information on this subject to Cook and other voyagers and travellers, &c.

The employment of the men is chiefly fishing, &c. whilst the women manufacture their garments. Their ingenuity in this and in the mechanic arts is far from being inconsiderable; and in the imitative arts their skill is very great. On these subjects, however, we cannot enlarge: we have in general made it our business, and it certainly is our duty, to dwell, where it can be done, on the manners or religion of the inhabitants of the several places which come under our notice; and they who know the utility of this in developing the philosophy of the human mind, the most

important of all sciences, will not blame our intentions, even if they should not approve of the execution. In Cook's Voyages before referred to, we find the following observations on the religion and language of the inhabitants of Nootka Sound.

"Little knowledge we can be supposed to have acquired of the political and religious institutions established among these people. We discovered, however, that there were such men as chiefs, distinguished by the title of *Acweek*, to whom the others are, in some degree, subordinate. But the authority of each of these great men seems to extend no farther than to his own family, who acknowledge him as their head. As they were not all elderly men, it is possible this title may be hereditary.

"Nothing that we saw could give us any insight into their notions of religion, except the figures already mentioned, called *Klumma*. These, perhaps, were idols; but as the word *acweek* was frequently mentioned when they spoke of them, we may suppose them to be the images of some of their ancestors, whose memories they venerate. This, however, is all conjecture; for we could receive no information concerning them; knowing little more of their language than to enable us to ask the names of things, and being incapable of holding any conversation with the natives relative to their traditions or their institutions.

"Their language is neither harsh nor disagreeable, farther than proceeds from their pronouncing the *k* and *b* with less softness than we do. As to the composition of their language, we are enabled to say but little. It may, however, be inferred from their slow and distinct method of speaking, that it has few prepositions or conjunctions, and is destitute of even a single interjection to express surprise or admiration. The affinity it may bear to other languages, we have not been able sufficiently to trace, not having proper specimens to compare it with; but from the few Mexican words we have procured, there is an obvious agreement throughout the language, in the frequent terminations of the words in *l*, *tl*, or *z*.

"The word *wakash* was frequently in the mouths of the people of Nootka. It seemed to express approbation, applause, and friendship. Whenever they appeared to be pleased or satisfied at any sight or occurrence, they would call out *wakash! wakash!*—It is worthy of remark, that as these people do essentially differ from the natives of the islands in the Pacific Ocean, in their persons, customs, and language, we cannot suppose their respective progenitors to have belonged to the same tribe, when they emigrated into those places where we now find their descendants."

We cannot finish this article without taking notice of a circumstance, which at the time made a great noise in Europe, and which it is probable will find a place in the future histories of the contending countries.

A small association of British merchants resident in the East Indies had, early in the year 1786, formed the project of opening a trade to this part of the world, for the purpose of supplying the Chinese market with furs. The principal point towards which these expeditions were directed, was Port Nootka, or King George's Sound; and the adventurers, being in some degree satisfied with their traffic, took measures,

Nootka-Sound.

Nopal
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Norden.

in the year 1788, to secure to themselves a permanent settlement; at the same time that the shipping employed in this expedition was generally two, and never exceeded the amount of four, small vessels. The Spaniards conceived some jealousy of the intrusion of the English into a part of the world which they had long been desirous to regard as their exclusive property; and accordingly a Spanish frigate of 26 guns was dispatched from the province of Mexico, for the purpose of putting an end to this commerce. The Spanish frigate arrived in May 1789, and captured two English vessels in the following July, at the same time taking possession of the little settlement which had been formed upon the coast. Such, in short, is the circumstance which was likely to involve us in an expensive war. Happily, however, for both countries, and perhaps for Europe, the matter was at length, after great altercation, amicably settled; and it must still be so fresh in the memories of our readers, that we trust they will excuse us from enlarging further upon it—the whole article having extended perhaps to more than a sufficient length.

NOPAL, RAQUETTE, or *Indian fig*; plants so named by the Indians from which the cochineal is collected in Mexico. These plants bear fruits which resemble our figs; tinge the urine of those who eat them; and probably communicate to the cochineal the property which makes it useful to the dyer. The Indians of Mexico cultivate the nopal near their habitations, and sow, as it were, the insect which affords the cochineal. They make small nests of moss or fine herbs; put twelve or fourteen cochineals into each nest; place three or four of these nests on each leaf of the nopal; and fasten them there by the prickles of the plant. In the course of a few days, thousands of small insects issue out, and fix themselves upon the parts of the leaf which are best sheltered and afford the most nourishment. The cochineals are collected several times in the course of the year; and are deprived of life by scalding them, or by putting them into an oven. See COCHINEAL.

Plate
CCCXLVI

NOPALXOCHQUETZALLI, or NOPALCOCHQUETZALLI, the prickly pear of Mexico, and common over all the West Indies. See CACTUS.

NOPH. See MEMPHIS.

NORBURY, a town in England, in Staffordshire, on the south-west side of Eccleshall. Here is a surprising echo, which, taken 440 yards north-east from the manor-house, near a little bank under a wood side, repeats in a still day 10 or 11 syllables very distinctly, or 12 or 13, if spoke very quick. It is remarked that the banks of the Black Meer, in this parish, grow forward every year over the surface of the water, at the rate of three or four yards every seven years.

NORDEN (Frederic Lewis), an ingenious traveller and naval officer in the Danish service, was born at Gluckstadt in Holstein in the year 1708. He was well skilled in mathematics, ship-building, and especially in architecture; and in 1732 obtained a pension to enable him to travel for the purpose of studying the construction of ships, particularly the galleys and other rowing vessels used in the Mediterranean. He spent near three years in Italy; and Christian VI. being desirous of obtaining a circumstantial account of Egypt, Mr Norden at Florence received an order to

extend his travels to that country. How he acquitted himself in this commission, appears from his *Travels into Egypt and Nubia*, printed at Copenhagen in folio, 1756; and which were soon after translated into English by Dr Peter Templeman. In the war between England and Spain, Mr Norden, then a captain in the Danish navy, attended Count Ulric Adolphus, a sea captain, to England; and they went out volunteers under Sir John Norris, and afterwards under Sir Chaloner Ogle. During his stay in London, Mr Norden was made a fellow of the royal society, and gave the public drawings of some ruins and colossal statues at Thebes in Egypt, with an account of the same in a letter to the Royal Society, 1741. His health at this time was declining; and taking a tour to France, he died at Paris in 1742.

NORDHEIM, a town in Germany, in the Hanover quarter. Of the four larger towns of this principality, it is the third in order. It is situated on the Ruhme, which runs into the Leine. It contains 500 houses, and, beside a secularized Lutheran abbey, has one parish-church, and some charitable foundations, and also enjoys some manufactures.

NORES (Jafon de), a scholar, poet, and philosopher, was born at Nicosia in Cyprus. He lost his fortune when the Turks made themselves masters of that island in 1570. He retired to Padua; where he acquired great reputation by teaching moral philosophy. His character had that cast of severity which is often the consequence of scholastic habits. He was one of those men who discuss every thing without being capable of feeling any thing. The *Pastor Fido* of Guarini made its appearance; and pastorals became a fashionable species of reading throughout all Italy. Nores, who did not relish works of this kind, attacked the production of Guarini; who entirely confuted him in a little piece printed at Ferrara in 1588. Nores made a reply two years after; and the poet was preparing an answer still more severe than the former, when his antagonist died of grief occasioned by the banishment of his only son for having killed a Venetian in a duel. He left behind him a great many works, some in Italian, and others in Latin. The chief of his Italian works, are, 1. *The Poeticks*, Padua, 1588, 4to; this edition is rare. 2. *A Treatise on Republics*, 1578, 4to; which he forms on the model of that of the Venetians, his masters. 3. *A Treatise on the World and its Parts*, Venice, 1571, 8vo. 4. *Introduction to three books of Aristotle's Rhetoric*, Venice, 1584, 4to, valuable. 5. *A treatise on what Comedy, Tragedy, and Epic Poetry, may receive from Moral Philosophy*. His Latin works are, 1. *Institutio in Philosophiam Ciceronis*, Padua, 1576, 8vo. 2. *Brevis et distincta summa præceptorum de arte discendi, ex libris Ciceronis collecta*, Venice, 1553, 8vo; a good work. 3. *De Constitutione partium humanæ et civilis philosophiæ*, 4to. 4. *Interpretatio in artem poeticam Horatii*, &c. In all his works we remark great perspicuity and accuracy, profound erudition, happy expressions, an elevated and sometimes forcible style.—His son Peter Nores, successively secretary to several cardinals, at once a man of letters and a man of business, left behind him different manuscripts; among others, the life of Paul IV. in Italian.

NORFOLK, a county of England, so called from its

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Norfolk.

Norfolk.

its northern situation in respect of Suffolk, is bounded on the east and north by the German ocean; on the south by Suffolk, from which it is parted by the rivers Waveney, and the Lesser Ouse; and on the west it is separated from Cambridgeshire by the Greater Ouse, and from a small part of Lincolnshire by the Washes. According to Templeman, it extends in length 57 miles, in breadth 35, and 140 in circumference. It contains an area of 1426 square miles, one city, 32 market-towns, 711 villages, according to the book of rates; though some make them 1500, and 236,000 inhabitants, as some have it, and 283,000, according to others. It is divided into 31 hundreds, 164 vicarages, and 660 parishes.

The air differs in different parts of the county according to the soil, which in some places is marshy, especially on the sea coast, and there the air is foggy and unwholesome; in others it is clayey and chalky, poor, lean, and sandy, and there the air is good. The county is almost all champaign, except in some places, where rise gentle hills. The marsh-lands yield rich pasture for cattle; the clay-grounds pease, rye, and barley; and the sandy-heaths feed vast flocks of large sheep, of which some villages are said to keep 4000 or 5000. These heaths abound also in rabbits of a silver-grey colour. Walsingham is noted for producing the best saffron. Great quantities of mackerel and herring are caught upon the coasts of this county, the former in the spring, and the latter in September; especially at Yarmouth, where they are cured in a particular manner, and to great perfection. Wood and honey are also very plentiful in this county; and on the coasts jet and ambergrease are sometimes found. The inhabitants are generally strong and active, sagacious and acute. That they are so robust, is the more to be wondered at, because the common people live much on puddings, *Norfolk dumplings*. They are for the most part in easy circumstances, and were formerly very quarrelsome and litigious. In consequence of this disposition, lawyers swarmed among them to such a degree, that a statute was made so early as the reign of Henry VI. to restrain their number. The manufactures of the county, which is exceedingly populous, are chiefly woollen and worsted stuffs and stockings, for which they are well supplied with wool from the vast flocks of sheep bred in it. It gives title of duke to the elder branch of the family of Howard, lies in the diocese of Norwich, and sends twelve members to parliament, viz. two knights for the shire, two citizens for Norwich, and two burgesses for each of the boroughs of Lynn Regis, Great Yarmouth, Thetford, and Castle Rising.

The county is well watered, and supplied with fish by the rivers Yare, Thyrn, Waveney, the Greater and Lesser Ouse, and the Bure, besides rivulets. The Bure abounds in excellent perch, and the Yare has a fish peculiar to it called the *ruffe*. The latter rises about the middle of the county; and after being joined by the Waveney and Bure, falls into the sea at Yarmouth. At the equinoxes, especially the autumnal, the Ouse is subject to great inundations, being forced back by the sea, that enters it with great fury. This county was famous at a very early period for its fisheries, which were extensive and valuable, and seem to have been carried on with spirit. It has also

been remarkable, for at least 400 years past, for the manufacture of fine worsted stuffs.

NORFOLK, a county of Virginia contiguous to North-Carolina.

NORFOLK-Island, a pretty little island of the South Sea, lying in 29° 12' 30" south latitude, and 168° 16' east longitude. A colony was lately settled on it; and the following account of it is given in *Governor Phillip's Voyage to Botany Bay, &c.*

"Norfolk-Island is about seven leagues in circumference; and if not originally formed, like many other small islands, by the eruption of volcanic matter from the bed of the sea, must doubtless have contained a volcano. This conclusion is formed from the vast quantity of pumice-stone which is scattered in all parts of it, and mixed with the soil. The crater, or at least some traces of its former existence, will probably be found at the summit of a small mountain, which rises near the middle of the island. To this mountain the commandant has given the name of *Mount Pitt*. The island is exceedingly well watered. At or near Mount Pitt rises a strong and copious stream, which flowing through a very fine valley, divides itself into several branches, each of which retains sufficient force to be used in turning mills; and in various parts of the island springs have been discovered.

"The climate is pure, salubrious, and delightful, preserved from oppressive heats by constant breezes from the sea, and of so mild a temperature throughout the winter, that vegetation continues there without interruption, one crop succeeding another. Refreshing showers from time to time maintain perpetual verdure: not indeed of grass, for none has yet been seen upon the island; but of the trees, shrubs, and other vegetables, which in all parts grow abundantly. On the leaves of these, and of some kinds in particular, the sheep, hogs, and goats, not only live, but thrive and fatten very much. To the salubrity of the air every individual in this little colony can bear ample testimony, from the uninterrupted state of good health which has been in general enjoyed.

"When our settlers landed, there was not a single acre clear of wood in the island, and the trees were so bound together by that kind of creeping shrub called *supple jack*, interwoven in all directions, as to render it very difficult to penetrate far among them. The commandant, small as his numbers were at first, by indefatigable activity soon caused a space to be cleared sufficient for the requisite accommodations, and for the production of esculent vegetables of all kinds in the greatest abundance. When the last accounts arrived, three acres of barley were in a very thriving state, and ground was prepared to receive rice and Indian corn. In the wheat there had been a disappointment, the grain that was sown having been so much injured by the weevil as to be unfit for vegetation. But the people were all at that time in commodious houses; and, according to the declarations of Mr King himself, in his letters to Governor Phillip, there was not a doubt that this colony would be in a situation to support itself entirely without assistance in less than four years; and with very little in the intermediate time. Even two years would be more than sufficient for this purpose, could a proper supply of black cattle be sent.

"Fish

Norfolk,
Norfolk-
Island.

Norfolk-
Island

Norham.

"Fish are caught in great plenty, and in the proper season very fine turtle. The woods are inhabited by innumerable tribes of birds, many of them very gay in plumage. The most useful are pigeons, which are very numerous; and a bird not unlike the Guinea fowl, except in colour (being chiefly white), both of which were at first so tame as to suffer themselves to be taken by hand. Of plants that afford vegetables for the table, the chief are cabbage palm, the wild plantain, the fern tree, a kind of wild spinach, and a tree which produces a dis-inutive fruit, bearing some resemblance to a currant. This, it is hoped, by transplanting and care, will be much improved in size and flavour.

"But the productions which give the greatest importance to Norfolk-Island are the pines and the flax plant; the former rising to a size and perfection unknown in other places, and promising the most valuable supply of masts and spars for our navy in the East Indies; the latter not less, estimable for the purposes of making sail-cloth, cordage, and even the finest manufactures, growing in great plenty, and with such luxuriance as to attain the height of eight feet. The pines measure frequently 160, or even 180 feet in height, and are sometimes 9 or 10 feet in diameter at the bottom of the trunk. They rise to about 80 feet without a branch: the wood is said to be of the best quality, almost as light as that of the best Norway masts; and the turpentine obtained from it is remarkable for purity and whiteness. The fern tree is found also of a great height for its species, measuring from 70 to 80 feet, and affords excellent food for the sheep and other small cattle. A plant producing pepper, and supposed to be the true oriental pepper, has been discovered lately in the island, growing in great plenty; and specimens have been sent to England in order to ascertain this important point."

NORFOLK-Sound, according to the account of Captain George Dixon, is situated in $57^{\circ} 3'$ north latitude, and $135^{\circ} 36'$ west longitude. It is a very extensive place, but how far it stretches to the northward is not known. There may possibly be a passage through to the Bay of Islands, but neither is this certain. The shore, in common with the rest of the coast, abounds with pines; there is also great quantities of the witch-hazel. There are various kinds of flowering trees and shrubs, wild gooseberries, currants, and raspberries; wild parsley is found here in great plenty, and it eats excellently either as a salad or boiled amongst soup. The saranne, or wild lily-root, grows also in great plenty and perfection. There are a very few wild geese or ducks seen here, but they are shy and difficult of approach.

NORHAM, a town in England, in the county of Northumberland, on the river Tweed, near the mouth of the Till, under the castle, which was anciently erected on a steep rock moated round, for the better security against the incursions of the Scotch moss-troopers. It is of great antiquity; and its old church has lately received repairs, and been made a decent place of worship. Antiquities have been discovered here. The church had the privilege of a sanctuary. The castle has been frequently honoured with the presence of sovereigns, particularly Edward I. here received the oath of treaty

from John Baliol of Scotland. It has been a formidable structure, a great part of which is in ruins; the site of which, with its demesnes, consisted of 1030 acres.

NORIA, an hydraulic machine much used in Spain. It consists of a vertical wheel of 20 feet diameter, on the circumference of which are fixed a number of little boxes or square buckets, for the purpose of raising the water out of the well, communicating with the canal below, and to empty it into a reservoir above, placed by the side of the wheel. The buckets have a lateral orifice to receive and to discharge the water. The axis of this wheel is embraced by four small beams, crossing each other at right angles, tapering at the extremities, and forming eight little arms. This wheel is near the centre of the horse-walk, contiguous to the vertical axis, into the top of which the horse-beam is fixed; but near the bottom it is embraced by four little beams, forming eight arms similar to those above described, on the axis of the water wheel. As the mule which they use goes round, these horizontal arms, supplying the place of cogs, take hold, each in succession, of those arms which are fixed on the axis of the water wheel, and keep it in rotation.

This machine, than which nothing can be cheaper, throws up a great quantity of water; yet undoubtedly it has two defects: the first is, that part of the water runs out of the buckets and falls back into the well after it has been raised nearly to the level of the reservoir: the second is, that a considerable proportion of the water to be discharged is raised higher than the reservoir, and falls into it only at the moment when the bucket is at the highest point of the circle, and ready to descend.

Both these defects might be remedied with ease, by leaving these square buckets open at one end, making them swing on a pivot fixed a little above their centre of gravity, and placing the trough of the reservoir in such a position as to stop their progress whilst perpendicular; make them turn upon their pivot, and so discharge their contents.

From the reservoir the water is conveyed by channels to every part of the garden; these have divisions and subdivisions or beds, some large, others very small, separated from each other by little channels, into which a boy with his shovel or his hoe directs the water, first into the most distant trenches, and successively to all the rest, till all the beds and trenches have been either covered or filled with water.

Mr Townsend, from whom we have taken the above account, thinks, that on account of the extreme simplicity of this machine, it is an invention of the most remote antiquity. By means of it the inhabitants every morning draw as much water from the well as will serve through the day, and in the evening distribute it to every quarter according to the nature of their crops. The reservoirs into which they raise the water are about 20, 30, or even 40 feet square, and three feet high above the surface of the ground, with a stone cope on the wall, declining to the water for the women to wash and beat their cloths upon.

Our limits preclude us from following Mr Townsend farther in the description of a particular noria used at Barcelona; which he conceives to be the original chain-pump,

Noria.

Noricum
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Noris.

pump, or at least its parent. He compares it with similar instruments, and shows its advantages and disadvantages.

NORICUM (Ptolemy, Tacitus); a Roman province, situated between the Danube on the north, and thus separated from ancient Germany; the Alpes Noricæ on the south; the river *Ænus* on the west, which separates it from Vindelicia; and Mons Cetius on the east, which divides it from Pannonia. Now containing a great part of Austria, all Saltzburg, Stiria, and Carinthia. It was anciently a kingdom under its own kings (Cæsar, Velleius, Suetonius). *Norici* the people, subdued by Tiberius under Augustus, as allies of the Pannonii (Dio, Velleius). Tacitus reckons Noricum among those provinces which were governed by procurators, officers sent by the emperors to receive and dispose of the public revenue according to order. It was divided into two provinces, but at what time uncertain; supposed as low down as Dioclesian and Constantine, viz. the *Noricum Ripense*, running along the south side of the Danube; and the *Noricum Mediterraneum*, extending towards the Alps. How far each of these extended in breadth does not appear: all the account we have of the matter being from Sextus Rufus, and the *Notitia Imperii Occidentalis*. Anciently a country famous for its iron and steel (Horace); as is Stiria at this day, a part of Noricum. A climate cold and more sparingly fruitful (Solinus).

NORIN, a river which rises in a corner of the Venetian confines, that runs between the rugged marble hills, and is left entirely to itself from its very source; hence a vast tract of land is overflowed by it, and encumbered with reeds, willows, and wild elders. A small space of ground only remains dry between the roots of the hills and the marsh at a place called *Prud*, and that is all covered with pieces of ancient hewn stones, fragments of inscriptions, columns, and capitals, and bass-reliefs of the best age, worn and deformed by time, and the barbarism of the northern people, who begun on that side to destroy Narona. The inhabitants, who go often to cut reeds in the marsh, assert, that the vestiges of that large city may still be seen under water. It appears to have been extended over the plain a great way, and undoubtedly it was three miles in length at the foot of the hills. The ancient road is now under water; and it is necessary to ascend a very steep road, in order to pass the point of a craggy hill, on which probably before the Roman times those fortifications were erected that cost Vetinius so much labour.

NORIS (Henry), cardinal, who was a great ornament of the order of the monks of St Augustine, was descended from the president Jason, or James de Noris, and born at Verona 1631. He was carefully educated by his father Alexander Noris, originally of Ireland, and well known by his History of Germany. He discovered from his infancy an excellent understanding, great vivacity, and a quick apprehension. His father instructed him in the rudiments of grammar, and procured an able professor of Verona, called *Maffoleim*, to be his preceptor. At 15 he was admitted a pensioner in the Jesuits college at Rimini, where he studied philosophy; after which he applied himself to the writings of the fathers of the church, particularly those of St Augustine: and taking the habit in

N° 243.

the convent of the Augustine monks of Rimini, he distinguished himself among that fraternity in a short time by his erudition; inasmuch, that as soon as he was out of his noviciate or time of probation, the general of the order sent for him to Rome, in order to give him an opportunity of improving himself in the more solid branches of learning. He did not disappoint his superior's expectations. He gave himself up entirely to his study, and spent whole days, and even nights, in the library of the Angeliques of St Augustine. His constant course was to stick to his books 14 hours a day; and this course he continued till he became a cardinal. By this means he became qualified to instruct others; and on this errand he was sent first to Pezaro, and thence to Peroufa, where he took his degree of doctor of divinity; after which proceeding to Padua, he applied himself to finish his History of Pelagianism. He had begun it at Rome at the age of 26; and having completed his design, the book was printed at Florence and published in 1673. The great duke of Tuscany invited him the following year to that city, made him his chaplain, and professor of ecclesiastical history in the university of Pisa, which his highness had founded with that view.

In his history he set forth and defended the condemnation pronounced, in the eighth general council, against Origen and Mopsuesta, the first authors of the Pelagian errors: he also added An Account of the Schism of Aquileia, and a Vindication of the Books written by St Augustine against the Pelagians and Semi-Pelagians. The work had procured him a great reputation, but met with several antagonists, to whom he published proper answers: the dispute grew warm, and was carried before the sovereign tribunal of the inquisition. There the history was examined with the utmost rigour, and the author dismissed without the least censure. It was reprinted twice afterwards, and Mr Noris honoured by Pope Clement X. with the title of Qualificator of the Holy Office. Notwithstanding this, the charge was renewed against the Pelagian History, and it was dilated afresh before the inquisition in 1676; but it came out again with the same success as at first. Mr Noris was now suffered to remain in peace for sixteen years, and taught ecclesiastical history at Pisa, without any molestation, till he was called to Rome by Innocent XII. who made him under-librarian of the Vatican in 1692. This post was the way to a cardinal's hat; his accusers therefore took fresh fire, and published several new pieces against him. Hence the Pope appointed some learned divines, who had the character of having taken neither side, to re-examine Father Noris's books, and make their report of them. Their testimony was so advantageous to the author, that his holiness made him counsellor of the inquisition. Yet neither did this hinder one of his adversaries, the most formidable on account of his erudition, to rise up against him, and attack him warmly, under the assumed title of a *Scrupulous Doctor of the Sorbonne*. Noris tried to remove these scruples in a work which appeared in 1695, under the title of An Historical Dissertation concerning one of the Trinity that suffered in the Flesh; wherein, having justified the monks of Scythia, who made use of that expression, he vindicated himself also from the imputation of having attained the Pope's infallibility, of

Noris.

Norkoping, of having abused Vincentius Lirinensis, and other bishops of Gaul, as favourers of Semi-pelagianism, and of having himself gone into the errors of the bishop of Ypres.

His answers to all these accusations were so much to the satisfaction of the Pope, that at length his holiness honoured him with the purple in 1695. After this, he was in all the congregations, and employed in the most important affairs; so that he had little time to spend in his study, a thing of which he frequently complained to his friends. Upon the death of cardinal Casanati, he was made chief library-keeper of the Vatican in 1700; and two years afterwards nominated, among others, to reform the calendar: but he died at Rome in 1704 of a dropsy. He was one of the most learned men in the last century: his writings abound with erudition, and are very elegantly finished. He was a member of the academy; whence he assumed the name of Eucrates Agoretico. His works are numerous, and were published at Verona, in 1729 and 1730, in five volumes folio.

NORKOPING, a town of Sweden, in the province of East Gothland, in east longitude $15^{\circ} 30'$, latitude $58^{\circ} 20'$. Its name signifies "the northern market" in the Swedish language. It stands on the banks of a large river called *Motala*, which coming from the lake *Vetter*, falls a little lower into a gulf called *Braviken*. It is the largest and most populous town in Sweden, next to Stockholm, conveniently situated near the sea on a navigable river, which brings large vessels up to the middle of the town. There are some handsome streets, and the houses in general are neatly built. Some of the churches are worth seeing; but the greatest curiosity are the famous copper mines, where there is a vast number of people constantly at work. In this article the town carries on a very good trade; as also in several other manufactures, as leather, steel, and guns, which they make the best in Sweden.

It covers a large space of ground, being ten miles in circumference; but the houses are small and scattered, and the inhabitants do not exceed 10,000. The river *Motala* flows through the town, forms a series of cataracts, and is divided into four principal streams, which encircle several rocky islands, covered with houses and manufactories. At the extremity of the town it is navigable for small vessels. Several manufactories are established in the town; 55 fabrics of cloth, which employ 1500 men; 3 sugar-houses; 1 of snuff; 50 mills for grinding corn, which is exported in large quantities; and a brass foundery. A salmon-fishery gives employment and riches to many of the inhabitants.

NORMANDY, a province of France, bounded on the north by the English channel; on the east by Picardy and the isle of France; on the south by Perche and Maine, and one part of Bretagne; and on the west by the ocean. It is about 155 miles in length, 85 in breadth, and 600 in circumference. It is one of the most fertile, and brings in the largest revenue of the kingdom. It abounds in all things except wine, but they supply that defect by cyder and perry. There are vast meadows, fat pastures, and the sea yields plenty of fish. It contains iron, copper, and a great number of rivers and harbours. It carries

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on a great trade, is very populous, and comprehends a vast number of towns and villages. It is divided into the Upper and Lower; the Upper borders upon Picardy, and the Lower upon Bretagne. It contains seven dioceses or bishoprics, Rouen, Bayeux, Avranches, Evreux, Sées, Lisieux, and Coutances, in which they compute 4189 parishes, and 80 abbeys. The inhabitants are ingenious, and capable of understanding any arts and sciences, but they are chiefly fond of law. The Normans, a people of Denmark and Norway, having entered France under Rollo, Charles the Simple ceded this country to them in 912, which from that time was called *Normandy*, and contains about 8200 square miles. Its chief city is Rouen. Rollo was the first duke, and held it as a fief of the crown of France, and several of his successors after him, till William, the seventh duke, conquered England in 1066: from which time it became a province of England, till it was lost in the reign of king John, and reunited to the crown of France; but the English still keep the islands on the coasts of Normandy.

The principal rivers are the Seine, the Eure, the Aure, the Iton, the Dive, the Andelle, the Rille, the Touque, the Drôme, and the Orne: among the seaports, the principal are those of Dieppe, Havre, Honfleur, Cherbourg, and Granville. Rouen is the principal city.

NORMANS, a fierce warlike people of Norway, Denmark, and other parts of Scandinavia. They at different times over-ran and ravaged most countries in Europe: to the respective histories of those countries we therefore refer for a fuller account of them, as it is impossible to enlarge upon particulars in this place without repeating what has been already said, or may be said, in different parts of the work.

NORMAN Characters, a species of writing introduced into England by William I. From some old manuscripts the Norman writing appears to have been composed of letters nearly Lombardic. In regal grants, charters, public instruments, and law proceedings, this character was used with very little variation from the reign of the Conqueror to that of Edward III. See WRITING.

NORRIS, or **NORIS**. See **NORIS**.

NORRIS (John), a learned English divine and Platonic philosopher, was born in 1657 at Collingborne-Kingston, in Wiltshire, of which place his father Mr John Norris was then minister. He bred his son first at Winchester school, and afterwards sent him to Exeter college in Oxford, where he was admitted in 1676; but was elected fellow of All Souls in 1680, soon after he had taken his degree of bachelor of arts. From his first application to philosophy, Plato became his favourite author; by degrees he grew deeply enamoured with the beauties of that divine writer, as he thought him; and took an early occasion to communicate his ideal happiness to the public, by printing an English translation of a rhapsody, under the title of *The Picture of Love unveiled*, in 1682. He commenced master of arts in 1684, and the same year opened a correspondence with that learned mystic divine Dr Henry More of Christ's college in Cambridge. He had also a correspondence with the learned lady Masham, Dr Cudworth's daughter, and the ingenious Mrs Astell. He resided at his college, and had been

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in holy orders five years, when he was presented to the rectory of Newton St Loe, in Somersetshire, 1689; upon which occasion he married and resigned his fellowship. In 1691, his distinguished merit procured him the rectory of Bemerton, near Sarum. This living, upwards of 200 l. a-year, came very seasonably to his growing family; and was the more acceptable, for the easiness of the parochial duty, which gave him leisure to make an addition to his revenues by the fruits of his genius; the activity of which produced a large harvest, that continued increasing till 1710. But this activity seems to have become fatal to him; for towards the latter end of his life, he grew very infirm, and died in 1711, in his 55th year, at Bemerton. He was interred in the chancel of that church, where there is a handsome marble monument erected to his memory, with this inscription: "H. S. E. Johannes Norris, parochiæ hujus rector, ubi annos viginti bene latuit curæ pastorali et literis vacans, quo in recessu sibi posuit late per orbem sparsa ingenii paris ac pietatis monumenta. Obiit an. Dom. 1711, ætatis 54." As to his character, he had a tincture of enthusiasm in his composition, which led him to imbibe the principles of the idealists in philosophy, and the mystics in theology; and the whole turn of his poetry shows, that this enthusiasm alone made him a poet. As an idealist, he opposed Locke, and adorned Malebranche's opinion, of seeing all things in God, with all the advantages of style and perspicuity of expression. In short, his errors, which are harmless enough of themselves, ought to be easily pardoned, on account of the general excellence of his writings, especially upon subjects of practical divinity, which are universally esteemed.

NORTH, one of the four cardinal points of the world; being that point of the horizon which is directly opposite to the sun in meridian. The north wind is generally accompanied with a considerable degree of cold. It sometimes blows with almost irresistible fury. It is often mentioned by the classic authors under the name of *Boreas*, which is of Greek original. See *BOREAS*.

NORTH Pole. See *POLE*.

NORTH (Dudley, lord), the third baron of that accomplished family, was one of the finest gentlemen in the court of king James; but in supporting that character, dissipated and gamed away the greatest part of his fortune. In 1645, he appears to have acted with the parliament; and was nominated by them to be administrator of the admiralty, in conjunction with the great earls of Northumberland, Essex, Warwick, and others. He lived to the age of 85, the latter part of which he passed in retirement; and wrote a small folio of miscellanies, in prose and verse, under this title, *A Forest promiscuous of several Seasons Productions*, in four parts, 1659.

NORTH (Dudley, lord), son of the former, was made knight of the bath in 1616, at the creation of Charles prince of Wales; and sat in many parliaments, till excluded by the prevailing party in that which condemned the king. From that period lord North lived privately in the country, and towards the end of his life entertained himself with books, and, as his numerous issue required, with economy; on which he wrote a little tract, called *Observations and advices economical*, 12mo. His other works are, *Passages re-*

lating to the long parliament; The history of the life of Lord Edward North, the first Baron of the family, addressed to his eldest son; and a volume of *Essays*.

NORTH (Francis lord Guildford, lord-keeper of the great-seal in the reigns of Charles II. and James II.) was a third son of the second Dudley lord North, baron of Kertling; and studied at St John's college in Cambridge, from whence he removed to the Middle Temple. He acquired French, Italian, Spanish, and Dutch; and became not only a good lawyer, but was well versed in history, mathematics, philosophy, and music. He was afterwards made the king's solicitor-general, and was chosen to represent the borough of Lynn in parliament. He succeeded Sir Heneage Finch in the post of attorney-general; and lord chief-justice Vaughan, in the place of lord chief-justice of the common pleas. He was afterwards made keeper of the great seal; and in 1683 was created a baron, by the title of *Lord Guildford*. He died at his house at Wroxtton in 1685. He wrote a philosophical essay on music; a paper on the gravitation of fluids, considered in the bladders of fishes, printed in Lowthorp's abridgement of the *Philosophical Transactions*; and some other pieces.

NORTH (Right Hon. Frederick), earl of Guildford, lord North, lord warden and admiral of the Cinque Ports, governor of Dover castle, lord lieutenant and custos rotulorum of Somersetshire, chancellor of the university of Oxford, recorder of Gloucester and Taunton, an elder brother of the Trinity-house, president of the Foundling hospital and of the Asylum, a governor of the Turkey Company and of the Charter house, K. G. and LL. D. was born April 13. 1732; and married, May 20. 1756, Miss Ann Speke, an heiress of the ancient family of Dillington in Somersetshire, by whom he has left two sons and three daughters: the eldest son George-Augustus, born Sept. 11. 1757, and married, Sept. 30. 1785, to Miss Hobart, succeeds to the earldom and estates. The late earl succeeded his father August 4. 1790. His lordship succeeded the celebrated Mr Charles Townsend as manager of the house of commons and chancellor of the exchequer; and in 1770, on the resignation of the duke of Grafton, was made first lord of the treasury; in which office he continued until the close of the American war, or rather until the formation of the Rockingham ministry, which began the business of peace with the colonies. He was a man of strong mental faculties; and as an orator, at once commanded attention and enforced conviction; but taking the helm at a time when the king's party were unpopular, and when it was supposed that the late earl of Bute was the great machine by which the cabinet was moved, so he continued in that state of unpopularity until he resigned the seals. During the whole of his premiership (and to conduct the helm at that time required uncommonly great abilities) he studiously avoided imposing any taxes that should materially affect the lower class of people. The luxuries, and not the necessities, of life were repeated objects of his budget. As a financier, he stood high, even in the opinion of opposition; and they were a combination of all the great talents in the kingdom: but, fatally wedded to the destructive plan of subduing the republican

North.

North || North-west Passage. republican spirit of the Americans, his administration will not only stand marked in the page of history with an immense waste of public treasure, but it will appear besprinkled with the kindred blood of thousands of British subjects. To the very last moment he spoke in the senate, however, he defended that war; and said, he was then, as he was formerly, prepared to meet the minutest investigation as to his conduct in that business; which nothing but the unforeseen intervention of France could have prevented from being crowned with success. His lordship was one of the firmest and most strenuous supporters of the constitution in church and state. He died on the 5th of August 1792. His recollection he retained to his last moments: his family, except lord North, who came within a few minutes afterwards, were assembled round his bed, and he took leave of them individually. Their grief did not suffer them to leave the room for some time after the event; and Lady Caroline Douglas was at last forced from it. Even Dr Warren, who must be strengthened as far as habit can operate against nature to endure such scenes, ran from this, convulsed with sorrow. If any extent of sympathy can lessen affliction, this family may find such relief; for perhaps no man was ever more generally beloved by all who had access to him than the earl of Guildford.

We may form an opinion of the estimation the celebrated university of Oxford entertained of their chancellor while living, by the very great honour they paid to his remains. About five o'clock in the afternoon of the 15th, the great bell at St Mary's church at Oxford rang out, which was a signal that the funeral procession had arrived in the environs of that city. The officers of the university, and the whole body of resident students, were previously assembled in Magdalen College, in order to pay some tribute to the memory of their deceased chancellor. They joined the procession at Magdalen Bridge, and paraded on foot before the hearse up the high-street to Carfax; from thence down the corn-market to St Giles's church at the town's end, in a most solemn manner. Here they halted, and opening to the right and left, the hearse and other carriages passed through, the whole university being uncovered. The hearse and attendants then proceeded to Banbury, where his Lordship's remains were deposited in the family vault.

NORTH-Cape, the most northerly promontory in Europe, on the coast of Norway. E. Long. 21. 0. N. Lat. 78. 0.

NORTH-Ferry, a small village, on the north side of the Firth of Forth, at the Queen's-Ferry passage. There was here formerly a chapel, served by the monks of Dunfermline, and endowed by Robert I. Near it are large granite quarries, which partly supply London with paving stones, and employ many vessels for the conveyance. "The granite (Mr Pennant says) lies in perpendicular strata, and above is a reddish earth, filled with micaceous friable nodules."

NORTH-Foreland, a cape or promontory of Kent, in the isle of Thanet, four miles east of Margate. Between this and the South-Foreland are the Downs, through which all ships pass that are bound to or from the west. E. Long. 1. 25. N. Lat. 51. 25.

NORTH-West Passage, a passage to the Pacific Ocean through Hudson's Bay or Davis's Straits, and which hath been frequently attempted without success; not-

withstanding which, many people are still of opinion that it is practicable.

The idea of a passage to the East Indies by the north pole, or through some opening near to it, was suggested as early as the year 1527. The person who had the honour to conceive this idea was Robert Thorne, a merchant of Bristol, who addressed two papers on the subject, the one to king Henry VIII. the other to Dr Ley, ambassador from that monarch to the emperor Charles V. To remove any objection to the undertaking, which might be drawn from the supposed danger, he insists, in his address to the king, upon the great advantages of constant day-light in the polar seas, and the probability of the climate being in those regions temperate during the summer months. In the paper addressed to Dr Ley, he observes that cosmographers may as probably be mistaken in the opinion which they entertain of the polar regions being impassable from extreme cold, as it has been found they were in supposing the countries under the line to be uninhabitable from excessive heat.

The possibility of the passage was, in consequence of these addresses, very generally supposed; and in 1557, Sir Martin Forbisher sailed to 62° north latitude, where he discovered the straits which have since bore his name. In 1577, Barne, in a book intitled the *Regiment of the Sea*, mentions a north-west passage as one of the five ways to Cathay; and dwells on the mildness of the climate, which, from the constant presence of the sun during summer, he imagines must be found near the pole. In 1578, George Best, a gentleman who had been with Sir Martin Forbisher in his voyages of discovery, wrote a very ingenious discourse to prove all parts of the world habitable. It does not, however, appear that any voyage was undertaken, for the express purpose of attempting to sail to India in a north-west direction, till the year 1607, when Henry Hudson was sent, at the expence of some merchants in London, to discover a passage by the north pole to Japan and China. He sailed from Gravesend on the 1st of May, and on the 21st of June fell in with the land to the westward, in latitude 73°, which he named *Hold-with-hope*. On the 27th he discovered Spitzbergen, and met with much ice. The highest latitude in which he made an observation was 80° 27'. See HUDSON.

In March 1609, Jones Poole was sent by Sir Thomas Smith, and the rest of the Muscovy company, to make further discoveries towards the north pole. After great severity of weather, and much difficulty from ice, he made the south part of Spitzbergen on the 16th of May; and sailing along and sounding the coast, he made many accurate discoveries; but was not in that voyage able to proceed beyond 79° 50'. He was again employed (1611), in a small vessel called the *Elisabeth*, to attempt the north-west passage; but after surmounting numberless difficulties, and penetrating to 80° of latitude, he lost his ship at Spitzbergen. Two voyages, equally unsuccessful, were made in 1614 and 1615, by Baffin and Fotherby; the latter of whom concludes the account of his discoveries and dangers, with exhorting the company which employed him not to adventure more than 150 or 200 pounds at most on yearly voyages to these seas.

Hitherto nothing had been done in this great undertaking but by private adventurers, fitted out for

North-west
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the double purpose of discovery and present advantage; and the polar regions were suffered to remain unexplored in that direction, from the year 1615 till 1773, when the earl of Sandwich, in consequence of an application which had been made to him by the Royal Society, laid before his majesty a proposal for an expedition to try how far navigation is practicable towards the north pole. Upon receiving this proposal, his majesty was pleased to direct that the voyage should be immediately undertaken, with every assistance that could contribute to its success. Accordingly, the Racehorse and Carcass bombs were fitted out for the purpose, and the command of the expedition given to Captain Phipps, now Lord Mulgrave. His Lordship's instructions were to proceed up to the pole, or as far towards it as possible, and as nearly upon a meridian as the ice or other obstructions should admit; and during the course of the voyage, to make such observations of every kind as might be useful to navigation, or tend to the promotion of natural knowledge. A very accurate account of this voyage was published by his Lordship in 1774. He had, by exerting all the powers of a skilful and intrepid seaman, forced his way, on the 1st of August, to 80° 37'; but could proceed no farther, as he was there opposed by one continued plain of smooth unbroken ice, bounded only by the horizon.

Many other attempts have been made to discover this passage, by sailing along the western coast of America; but hitherto none of them has been crowned with success. So early as 1579, Sir Francis Drake assured queen Elisabeth that he had sailed some leagues up the straits of Anian (see ANIAN), and discovered New Albion, to the north of California; but the strait is now known to have no existence; and Drake's real discoveries were not improved. In 1630, king Cha. I. sent captain Luke Fox in one of his pinnaces to attempt the passage; but of his proceedings we know nothing, but that he reached port Nelson in Hudson's bay, where he found some remains of former navigators. Next year captain James was fitted out by the merchants of Bristol for the same purpose. James was one of the ablest navigators that ever sailed from England or any other country; and his voyages to the north were printed in 1633. After all the experiments he had made, he concluded that there was no such passage; or if there be, he affirmed that the discovery of it would not be attended with those advantages which are commonly expected. His reasons, however, for these opinions have been answered, and many subsequent attempts have been made to perform what he thought impossible. The arguments for a north-west passage were so plausible, that, in 1744, an act of parliament was passed to encourage the discovery of it. Among many others, captain Cook attempted the discovery in vain, and thence adopted James's opinion. (See *Cook's Discoveries*, n° 103.) This celebrated navigator, after having proceeded northwards to the western extremity of America, and ascertained the proximity of the two great continents of Asia and America, returned to the Sandwich islands, firmly persuaded of the impracticability of a passage in that hemisphere from the Atlantic into the Pacific Ocean, either by an eastern or a western course.

Later voyagers, however, have pretended to detect

some errors in Cook's discoveries; and the author of a small tract, intitled *An authentic Statement of all the Facts relative to Nootka-Sound*, goes a great way to make the discovery not yet hopeless. In his account of the expedition under the direction of Messrs Etches, he says, that "one of the first discoveries made by these ships was, that what was by the immortal Cook laid down as a continuation of the north-west continent of America, and lying between the northern latitudes of 48 and 57, is on the contrary an extensive cluster of unexplored islands inhabited by numerous tribes of friendly Indians, with whom a regular connection was formed."

These islands they discovered, contrary to the assertion of captain Cook, to conceal the opening of a vast inland sea, or archipelago, in all probability equal to the Mediterranean or Baltic seas, and dividing the great northern continent of America. The Princess Royal penetrated some hundred leagues among them, in a north-east course, to within 200 leagues of Hudson's house, but had not then an opportunity to explore the extreme termination of that archipelago, their commercial concerns obliging them to return to the China market; but the commanders had the strongest reasons to believe, had time favoured their survey, that they should have been able to discover the long-wished for passage between the Atlantic and South Sea. They conceived, that should neither the inland arm of the sea through which the Princess Royal penetrated, nor a large strait named Sir Charles Middleton's, about three degrees to the southward, be found to reach across the continent, yet that the land barrier must be very inconsiderable; and that at the extremity of this bay a practicable passage, either by rivers or lakes, will, by perseverance, be found terminating towards Hudson's bay.

Upon the whole, however, it appears to us extremely doubtful whether there be such a passage; but it is much more likely to be discovered, if discovered at all, by the progressive advances of mercantile enterprise than by any immediate expedition undertaken for that purpose.

NORTH-East Passage, a passage to the East Indies along the northern coasts of Asia, which, like the former, hath frequently been attempted, but hitherto without success. The first attempt was made in 1553 by Sir Hugh Willoughby, who commanded three ships. He departed from the Thames and sailed to the North Cape, where one of his ships left him, and returned home. The other two ships being separated, Sir Hugh proceeded farther northward, and discovered that part of Greenland which the Dutch have since called *Spitzberg*; but the severity of the cold obliging him to return to the southward, he was forced, by bad weather, into the river Arzina, in Muscovite Lapland, where, not being able to come out, he was found the next spring frozen to death, with all his ship's company; having the notes of his voyage and his last will lying before him, whereby it appeared that he lived till January. But Richard Chancellor, in the third ship, with better success, in the meanwhile entered Wardhuys, where he waited some time for his companions to no purpose; uncertain whether they were lost, or driven farther by stress of weather. He held a council on what he should do; whether to return

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return, or pursue his voyage. Whatever danger might be in the last, every one agreed to it, that they might not seem to have less courage than their captain. They therefore set sail, and in a few days found themselves in a sea where they could no longer perceive any night. This ship, wandering about, entered soon after into a large bay or gulf. Here they cast anchor, in sight of land; and while they were examining the coast, they discovered a fishing boat. Chancellor getting into his sloop, went towards it; but the fishermen took to flight. He followed, and, overtaking them, showed them such civilities as conciliated their affections to him; and they carried him to the place where now is the famous port of St Michael the Archangel. These people immediately spread through all the coasts an account of the arrival of those strangers; and people came from several parts to see them, and ask them questions. They, in their turn, examined the others, and found that the country they were in was Russia, governed by the mighty Emperor John Basilowitz. Chancellor from Archangel travelled on sledges to the Czar at Moscow; from whom, overjoyed at the prospect of opening a maritime commerce with Europe, he obtained privileges for the English merchants, and letters to King Edward VI. who was not, however, alive to receive them.

In 1585, Mr John Davis in two barks discovered Cape Desolation, which is supposed to be part of Greenland; and two years after advanced as far as Lat. 72°, where he discovered the strait which still bears his name. To enumerate all the attempts which have been made to discover a north-east passage, would swell the article to very little purpose. The English, Dutch, and Danes, have all attempted it without success. The last voyage from England for this purpose was made in 1676, under the patronage of the duke of York. That unfortunate prince, who was on all occasions earnest for the promotion of commerce, and the Lord Berkeley, &c. fitted out a ship, commanded by Captain Wood, for an attempt once more to find a north-east passage to India, accompanied with a ship of the king's. They were encouraged to this attempt, after it had been so long despaired of, by several new reports and reasonings: some of which seem not to have been very well grounded—As,

“1. On the coast of Corea, near Japan, whales had been found with English and Dutch harpoons sticking in them. This is no infallible proof that ships could get thither by a north-east passage, although whales might.

“2. That, 20 years before, some Dutchmen had sailed within one degree of the north pole, and found it temperate weather there: and that therefore William Barents, the Dutch navigator who wintered at Nova Zembla in the year 1596, should have sailed further to the north before turning eastward; in which case, said they, he would not have found so much obstruction from the ice.

“3. That two Dutch ships had lately sailed 300 leagues to the eastward of Nova Zembla; but their East India company had stifled that design, as against their interest:—and such like other airy reports. But this attempt proved very unfortunate. They doubled the North Cape, and came among much ice and drift

wood, in 76° of north latitude, steering to the coast of Nova Zembla, where the king's ship struck upon the rocks, and was soon beat to pieces; and Captain Wood returned home with an opinion, “that such a passage was utterly impracticable, and that Nova Zembla is a part of the continent of Greenland.”

These passages, however, are not yet deemed impracticable by all. The Count de Buffon holds it for certain, that there is a passage from Europe to China by the north sea. The reason why it has been so often attempted in vain, he thinks, is, that fear prevented the undertakers from keeping at a sufficient distance from land, and from approaching the pole, which they probably imagined to be an immense rock. Hence he affirms, that if any farther attempts be made to find a passage to China and Japan by the north seas, it will be necessary to keep at a distance from the land and the ice; to steer directly towards the pole; and to explore the most open seas, where unquestionably, says he, there is little or no ice. This opinion has been lately revived by the Hon. Daines Barrington, who says, that if the passage be attempted by the pole itself, he has very little doubt of its being accomplished. See *North-Pole*.

NORTHAMPTON, a town in England, capital of a county of the same name, situated in W. Long. 0. 55. N. Lat. 52. 15. According to Camden, it was formerly called *North-afandon*, from its situation to the north of the river Nen, called anciently *Aufona*, by which and another lesser river it is almost inclosed. Dr Gibson says, that the ancient Saxon annals called both it and Southampton simply *Hamton*; and afterwards, to distinguish them, called the one, from its situation, *Southampton*, and the other *Northampton*; but never *North-afandon*. Though it does not appear to be a place of very great antiquity, nor to have emerged from obscurity till after the conquest, it has sent members to parliament since the reign of Edward I. and being in the heart of the kingdom, several parliaments have been held at it. There was also a castle, and a church dedicated to St Andrew, built by Simon de Sancto Licio, commonly called *Senlez*, the first earl of Northampton of that name. It is said to have been burnt down during the Danish depredations; but in the reign of St Edward it appears to have been a considerable place. It was besieged by the barons in their war with King John; at which time that military work called *Hunscill*, is supposed to have been raised. In the time of Henry III. it sided with the barons, when it was besieged and taken by the king. Here the bloody battle was fought in which Henry VI. was taken prisoner. It was entirely consumed by a most dreadful fire in 1675; yet, by the help of liberal contributions from all parts of the country, it hath so recovered itself, that it is now one of the neatest and best-built towns of the kingdom. Among the public buildings, which are all lofty, the most remarkable are the church called *All-hallows* (which stands at the meeting of four spacious streets), the sessions and assize house, and the George-Inn, which belongs to the poor of the town. A county-hospital or infirmary has been lately built here, after the manner of those of Bath, London, Bristol, &c. It has a considerable manufacture of shoes and stockings; and its fairs are noted for horses both for draught and saddle; besides,

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besides, it is a great thoroughfare for the north and west roads. It was formerly walled, and had seven churches within and two without. The horse-market is reckoned to exceed all others in the kingdom, it being deemed the centre of all its horse-markets and horse-fairs, both for saddle and harness, and the chief rendezvous of the jockies both from York and London. Its principal manufacture is shoes, of which great numbers are sent beyond sea; and the next to that, stockings and lace, as we have hinted at above. It is the richer and more populous, by being a thoroughfare both in the north and west roads; but, being 80 miles from the sea, it can have no commerce by navigation. The walls of this town were above two miles in compass. It is supposed to contain about 1083 houses, and 5200 inhabitants. It had formerly a nunnery in the neighbouring meadows, with several other monasteries; and of its very old castle on the west side of the town, a small part of the ruins are still to be seen. Some discontented scholars came hither from Oxford and Cambridge, about the end of the reign of Henry III. and, with the king's leave, prosecuted their studies here academically for three years; during which there was the face of an university, till it was put a stop to by express prohibition, because it was a damage to both universities. The public horse-races are on a neighbouring down, called *Pye-Leys*. In and about the town are abundance of cherry-gardens. Within half a mile of the town is one of the crosses erected by King Edward I. in memory of his Queen Eleanor, whose corpse was rested there in its way to Westminster. On the north side of the river, near that cross, many Roman coins have been ploughed up. At Guileborough, north-west of Northampton, are to be seen the vestiges of a Roman camp, the situation of which is the more remarkable, as lying between the Nen and the Avon, the only pass from the north to the south parts of England not intercepted by any river. This camp was secured only by a single intrenchment, which was, however, very broad and deep.

NORTHAMPTONSHIRE, a county of England, is situated in the very heart of the kingdom: bounded on the east by the counties of Bedford and Huntingdon; on the south by those of Buckingham and Oxford; on the west by Warwickshire; and on the north by the counties of Leicester, Rutland, and Lincoln, which are separated from it by the Lesser Avon, and the Welland. Its greatest length is about 50 miles, its greatest breadth about 20, and its circumference about 130. It contains 330 parishes. There are in it one city, 11 market-towns, 25,000 houses, and 150,000 inhabitants. Nine members are returned to parliament for this county, viz. two knights for the shire, two for the city of Peterborough, two for each of the towns of Northampton and Brockly, and one for Higham Ferrers. It lies in the Mid-land circuit, and in the diocese of Peterborough. As this county is dry, well cultivated, free from marshes, except the fens about Peterborough, in the centre of the kingdom, and of course at a distance from the sea, it enjoys a very pure and wholesome air. In consequence of this it is very populous, and so full of towns and churches, that 30 spires or steeples may be seen in many places

at one view; and even in the fens, the inhabitants seem to enjoy a good state of health, and to be little affected by the water which frequently overflows their grounds, especially in winter, but is never suffered to remain long upon it. Its soil is exceeding fertile both in corn and pasturage; but it labours under a scarcity of fuel, as it doth not produce much wood, and, by lying at a distance from the sea, cannot be easily supplied with coal. Its commodities, besides corn, are sheep, wool, black cattle, and saltpetre; and its manufactures are serges, tammies, shalloons, boots, and shoes. Besides many lesser brooks and streams, it is well watered by the rivers Nen, Welland, Ouse, and Leam; the three first of which are large, and for the most part navigable.

NORTHAMPTON, a county of north America, in Virginia, forming the south part of the peninsula on the eastern coast of Virginia.

NORTH ROCKS, (otherwise called *St Patrick's rocks*, from a seat of stone amongst them called *St Patrick's chair*, whence the rocks have taken this second name); situated in the harbour of Donaghadee, in the county of Down, and province of Ulster, in Ireland. From north to south they are about two thirds of a league, between which is clean good ground. But care must be taken of the south rock, on which many ships have perished: for it is overflowed by every tide, and no crew can save their lives if the wind blows high. This rock stands a full mile from the shore.

NORTH SEA. See *North SEA*.

NORTHERN LIGHTS, the same with AURORA BOREALIS, under which article we have given a copious account of this phenomenon, and of the supposed causes of it. Natural science, however, does not arrive at perfection at once, and it is well if it does so after trials repeated for years with care and accuracy. How far the causes that have been assigned for this appearance will account for it, or whether they will be able to remove all difficulties, it is not for us to determine; but it is the part of philosophers to hear all sides, and to attend with patient assiduity to every hypothesis, rejecting or receiving as reason, after the the strictest investigation, shall seem to favour the one side or the other. Wishing to lay before our readers every thing important either in science or in literature, we cannot let pass the opportunity which the present article affords us, of mentioning an hypothesis which Doctor Stearns, an American, formed, about the year 1788, to account for the appearances called *aurora borealis*, and *aurora australis*. For this last, see AURORA BOREALIS, n° 3.

Doctor Stearns supposes that these phenomena originate from aqueous, nitrous, sulphureous, bituminous, and other exhalations, from the fumes of various kinds of earths or other minerals, vegetables, animals, fires, volcanoes, &c. These, he thinks, become rarefied, and being charged with electrical fluid, become specifically lighter than the circumambient air: hence, of course, they ascend; and being elevated to the upper regions of the air and driven by the winds from warmer to colder climates, the cold makes them combine and stiffen. When they are afterwards agitated by different currents of air, they sparkle and crackle like the hairs of cats and other animals when stiffened with cold. This conuscation in quite cold atmospheres,

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spheres, and in those which are more temperate, appears in different positions in the horizon, zenith, or otherwise, according to the situation of the spectator, and the position of the elevated exhalations. The difference of colours the Doctor supposes to arise from the different qualities of the articles combined, those of the most inflammable nature shining with the greatest lustre.

The Doctor likewise tries to account for these lights not appearing, or but seldom appearing, in ancient times. The atmosphere, he thinks, was not impregnated with materials proper to produce them. He imagines that the increased consumption of fuel, in America in particular, the burning of volcanoes, and the approach of blazing stars, whose atmospheres have been so expanded by the sun's heat that part of them have fallen into the earth's atmosphere, and communicated to it new matter, have so changed and prepared our air, that whenever its consistence is proper, then, if the light of the sun and moon is not too powerful, the aurora borealis will appear.

NORTHUMBERLAND, the most northerly county of England, and formerly a distinct kingdom, is bounded on the north and west by the river Tweed, which divides it from Scotland, the Cheviot-hills, and part of Cumberland; washed on the east by the German Ocean; and separated from Durham on the south by the rivers Tyne and Derwent. This county, which gives the title of *duke* to a nobleman who married the daughter of Algernon duke of Somerset, whose mother was heiress of the Piercy family, extends about 66 miles in length from north to south, and about 47 in breadth from east to west. It is remarkably populous, containing 12 market-towns, 280 villages, and 460 parishes. The face of the country, especially towards the west, is roughened with huge mountains, the most remarkable of which are the Cheviot-hills, and the high ridge called *Ridesdale*; but the lands are level towards the sea-side and the borders of Durham. The climate, like that of every other mountainous country in the neighbourhood of the sea, is moist and disagreeable: the air, however, is pure and healthy, as being well ventilated by breezes and strong gales of wind; and in winter mitigated by the warm vapours from the two seas, the Irish and the German Ocean, between which it is situated. The soil varies in different parts of the county. Among the hills it is barren; though it affords good pasture for sheep, which cover those mountains. The low country, when properly cultivated, produces plenty of wheat, and all sorts of grain; and great part of it is laid out in meadow-lands and rich enclosures. Northumberland is well watered with many rivers, rivulets, and fountains: its greatest rivers are the Tweed and the Tyne. The Tyne is composed of two streams called *South* and *North Tyne*: the first rises on the verge of Cumberland, near Alston Moor; enters Northumberland, running north to Haltwessel; then bends easterly, and receiving the two small rivers East and West Alon, unites above Hexham with the other branch, taking its rise at a mountain called *Fane-head* in the western part of the county, thence called *Tine-dale*; is swelled in its course by the little river Shele; joins the *Read* near Billingham; and running in a direct line to the south-east, is united with the southern Tyne, forming

a large river that washes Newcastle, and falls into the German Ocean near Tinmouth. Northum-
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In all probability the mountains of Northumberland contain lead-ore and other mineralized metals in their bowels, as they in all respects resemble those parts of Wales and Scotland where lead mines have been found and prosecuted. Perhaps the inhabitants are diverted from inquiries of this nature, by the certain profits and constant employment they enjoy in working the coal pits, with which this county abounds. The city of London, and the greatest part of England, are supplied with fuel from these stores of Northumberland, which are inexhaustible, enrich the proprietors, and employ an incredible number of hands and shipping. About 658,858 chaldrons are annually shipped for London.

There are no natural woods of any consequence in this county; but many plantations belonging to the seats of noblemen and gentlemen, of which here is a great number. As for pot-herbs, roots, salading, and every article of the kitchen-garden and orchard, they are here raised in great plenty by the usual means of cultivation; as are also the fruits of more delicate flavour, such as the apricot, peach, and nectarine. The spontaneous fruits it produces in common with other parts of Great Britain, are the crab-apple, the sloe or bullace, the hazel-nut, the acorn, hips, and haws, with the berries of the bramble, the juniper, wood-strawberries, cranberries, and bilberries.

Northumberland raises a good number of excellent horses and black cattle, and affords pasture for numerous flocks of sheep; both the cattle and sheep are of a large breed, but the wool is coarser than that which the more southern counties produce. The hills and mountains abound with a variety of game, such as red deer, foxes, hares, rabbits, heathcock, grouse, partridge, quail, plover, teal, and woodcock: indeed, this is counted one of the best sporting counties in Great Britain. The sea and rivers are well stocked with fish; especially the Tweed, in which a vast number of salmon is caught and carried to Tinmouth, where being pickled, they are conveyed by sea to London, and sold under the name of *Newcastle Salmon*.

The Northumbrians were anciently stigmatized as a savage, barbarous people, addicted to cruelty, and inclined to rapine. The truth is, before the union of the two crowns of England and Scotland, the borderers on each side were extremely licentious and ungovernable, trained up to war from their infancy, and habituated to plunder by the mutual incursions made into each kingdom; incursions which neither truce nor treaty could totally prevent. People of a pacific disposition, who proposed to earn their livelihood by agriculture, would not on any terms remain in a country exposed to the first violence of a bold and desperate enemy; therefore the lands lay uncultivated, and in a great measure deserted by every body but lawless adventurers, who subsisted by theft and rapine. There was a tract 50 miles in length and 6 in breadth, between Berwick and Carlisle, known by the name of the *Debateable Land*, to which both nations laid claim, though it belonged to neither; and this was occupied by a set of banditti who plundered on each side, and what they stole in one kingdom, they sold openly in the other:

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Northwick

may, they were so dexterous in their occupation, that by means of hot bread applied to the horns of the cattle which they stole, they twisted them in such a manner, that, when the right owners saw them in the market, they did not know their own property. Wardens were appointed to guard the marches or borders in each kingdom; and these offices were always conferred on noblemen of the first character for influence, valour, and integrity. The English border was divided into three marches, called the *east*, *west*, and *middle marches*; the gentlemen of the country were constituted deputy-wardens, who held march-courts, regulated the watches, disciplined the militia, and took measures for assembling them in arms at the first alarm: but in the time of peace between the two nations, they were chiefly employed in suppressing the insolence and rapine of the borderers. Since the union of the crowns, however, Northumberland is totally changed, both with respect to the improvement of the lands, and the reformation of the inhabitants. The grounds, being now secure from incursion and insult, are settled by creditable farmers, and cultivated like other parts of the kingdom. As hostilities have long ceased, the people have forgot the use of arms, and exercised themselves in the more eligible avocations of peace; in breeding sheep and cattle, manuring the grounds, working at the coal-pits, and in different branches of commerce and manufacture. In their persons they are generally tall, strong, bold, hardy, and fresh-coloured; and though less unpolished than their ancestors, not quite so civilised as their southern neighbours. The commonalty are well fed, lodged, and clothed; and all of them remarkably distinguished by a kind of *shibboleth* or *whurle*, being a particular way of pronouncing the letter *R*, as if they hawked it up from the wind-pipe, like the cawing of rooks. In other respects, the language they speak is an uncouth mixture of the English and Scottish dialects. There is no material distinction between the fashionable people of Northumberland and those of the same rank in other parts of the kingdom: the same form of education will produce the same effects in all countries. The gentlemen of Northumberland, however, are remarkable for their courage, hospitality, and hard drinking. The number of inhabitants are reckoned 126,400, of houses 22,740.

A great number of Roman monuments have been found in this county; but the most remarkable curiosity of that kind consists in the remains of Hadrian's vallum and the wall of Severus. See *ADRIAN* note (A), and *SEVERUS'S Wall*.

The most noted towns in Northumberland, are Newcastle, Morpeth, Alnwick, Berwick, Hexham, and North Shields. It sends two members to parliament.

NORTHWICK, a small town of Cheshire, long celebrated for its rock-salt and brine pits. The stratum of salt lies about 40 yards deep; and some of them are hollowed into the form of a temple. The descent is through a dome, the roof supported by rows of pillars about two yards thick, and several in height; and when illuminated with a sufficient number of candles, they make a most magnificent appearance. Above the salt is a bed of whitish clay (*Argilla cerula-cinerea*), used in making the Liverpool earth-

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en-ware; and in the same place is also dug a good deal of the gypsum, or plaster-stone. The fossil salt is generally yellow, and semipellucid, sometimes debased with a dull greenish earth, and is often found, but in small quantities, quite clear, and colourless. The town is situated near the river Dane, and is tolerably handsome: it has a market on Fridays. It is 20 miles north-east of Chester, and 173 north-west of London. W. Long. 2. 36. N. Lat. 53. 16.

NORTON, in Cheshire, a good modern alms-house, founded by P—y Brook, Esq; on the site of a priory of canons regular of St Augustine, founded by William, son of Nigellus, A. D. 1135, who did not live to complete his design; for Eustace de Burgaville granted to Hugh De Catherine pastures for 100 sheep, in case he finished the church in all respects conformable to the intent of the founders. It was granted afterwards to R. Brooke, Esq.

NORTON'S SOUND, was discovered in capt. Cook's last voyage, and was so named in honour of Sir Fletcher Norton (Lord Grantley), a near relation of Mr, afterwards Dr, King. It extends as far as N. Lat. 64° 55'. There is no good station for ships, nor even a tolerable harbour in all the sound. Mr King, on his landing here, discerned many spacious valleys, with rivers flowing through them, well wooded, and bounded with hills of a moderate height. One of the rivers towards the north-west seemed to be considerable; and he was inclined to suppose, from its direction, that it discharged itself into the sea from the head of the bay. Some of his people, penetrating beyond this into the country, found the trees to be of a larger size the further they proceeded. E. Lon. 197. 13. N. Lat. 64. 31.

NORWAY, a country of Europe (for the map see *DENMARK*), lying between the 57th and 72d degrees of north latitude, and between the 5th and 31st degrees of longitude east from London; extending in length about 1000 miles, in a direct line from Lindefnaes, in the diocese of Christiansand, to the North Cape, at the extremity of Finmark. Its breadth, from the frontiers of Sweden westward to Cape Statt, may amount to about 300 miles; but from thence the country becomes gradually narrower towards the north. On the south it is bounded by the Schagen-rock, or Categate, the entrance into the Baltic; on the east it is divided from Sweden by a long ridge of high mountains; and on the west and north it is washed by the northern ocean. In the southern part of Norway, the country is craggy, abrupt, and mountainous, diversified sometimes with fertile and even delightful spots. In these respects it resembles Switzerland: the prospects and the meteorological phenomena seem to be very similar. The range of the thermometer is of great extent; in the summer having risen to 88°, and in the winter fallen to -40°: in general it is between 80° and -22°.

Respecting the population of Norway it is difficult to attain to certainty. An author of some note (Coxe) seems to think they amount to 750,000; but he appears to have over-rated them considerably.

The Norwegian peasants are free, well-clothed, well-lodged, spirited, active, frank, open, and undaunted. They are said to have a very considerable resemblance to the peasants of Switzerland. The soil is too thin

for

Norton,
||
Norway.

Norway. for the plough: corn is therefore obtained from the neighbouring states; and the chief employment of the peasants of Norway is grazing. The following extract from Mr Coxe, being a description of the scene near Christiana, is not beside our purpose, and may not perhaps be disagreeable to our readers.

Coxe's Travels. "As we approached Christiana, the country was more wild and hilly, but still very fertile and agreeable; and about two miles from the town we came to the top of a mountain, and burst upon as fine a view as ever I beheld. From the point on which we stood in raptures, the grounds laid out in rich enclosures, gradually sloped to the sea; below us appeared Christiana, situated at the extremity of an extensive and fertile valley, forming a semicircular bend along the shore of a most beautiful bay, which, being inclosed by hills, uplands, and forests, had the appearance of a large lake. Behind, before, and around, the inland mountains of Norway rose on mountains covered with dark forests of pines and fir, the inexhaustible riches of the north. The most distant summits were capped with eternal snow. From the glow of the atmosphere, the warmth of the weather, the variety of the productions, and the mild beauties of the adjacent scenery, I could scarcely believe that I was nearly in the 60th degree of northern latitude."

The coast of Norway, extending above 300 leagues, is studded with a multitude of small islands, affording habitation to fishermen and pilots, and pasture to a few cattle. They form an infinite number of narrow channels, and a natural barrier of rocks, which renders Norway inaccessible to the naval power of its enemies. Attempts of this kind are the more dangerous, as the shore is generally bold, steep, and impending; so that close to the rocks the depth of the sea amounts to 100, 200, or 300 fathoms. The perils of the north sea are moreover increased by sudden storms, sunk rocks, violent currents, and dreadful whirlpools. The most remarkable vortex on this coast is called *Moskoe-strom*, from the small island Moskoe, belonging to the district of Lofoden in the province of Nordland. In time of flood, the stream runs up between Lofoden and Moskoe with the most boisterous rapidity; but in its ebb to the sea, it roars like a thousand cataracts, so as to be heard at the distance of many leagues. The surface exhibits different vortices; and if in one of these any ship or vessel is absorbed, it is whirled down to the bottom, and dashed in pieces against the rocks. These violent whirlpools continue without intervals, except for a quarter of an hour, at high and low water, in calm weather; for the boiling gradually returns as the flood or ebb advances. When its fury is heightened by a storm, no vessel ought to venture within a league of it. Whales have been frequently absorbed within the vortex, and howled and bellowed hideously in their fruitless endeavours to disengage themselves. A bear, in attempting to swim from Lofoden to Moskoe, was once hurried into this whirlpool, from whence he struggled in vain for deliverance, roaring so loud as to be heard on shore; but, notwithstanding all his efforts, he was borne down and destroyed. Large trees being absorbed by the current, are sucked down, and rise again all shattered into splinters. There are three vortices of the same kind near the islands of Ferroe.

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Norway is divided into the four governments of Norway. Aggerhus, Bergen, Drontheim, and Wardhus, besides that of Bahus, which is now subject to Sweden. The province of Aggerhus comprehends the south-east part of Norway, extending in length about 300 miles. Its chief towns are Christiana, the see of a bishop, suffragan to the metropolitan see of Drontheim, where the sovereign court of justice is held, in presence of the viceroy and the governor of the province; Aggerhus, about 15 miles to the south-west of Christiana; Frederickshall or Frederickstadt, in the siege of which Charles XII. of Sweden lost his life; Saltzberg, Tonsberg, Alleen, Hammar, and Hollen.

The government of Bergen lies in the most southerly and westerly part of Norway, including the city of the same name, which is an episcopal see, and a place of considerable trade; and Staff-hanger, situated in the bay of Buckensior, about 80 miles to the southward of Bergen. The third province, called *Drontheim* or *Trontheim*, extends about 500 miles along the coast; and is but thinly peopled. The chief town Drontheim, seated on a little gulph at the mouth of the river Nider, is the only metropolitan see in Norway; and carries on a considerable trade in masts, deals, tar, copper, and iron. Leetstrand, Stronden, Scoerdale, Opdal, Romsdael, and Solendael, are likewise places of some traffic. The northern division of Drontheim, called the *sub-government of Salten*, comprehends the towns Melanger and Scheen. The province of Wardhus, extending to the North Cape, and including the islands, is divided into two parts; namely, Finmark and Norwegian Lapland. The chief town, which is very inconsiderable, stands upon an island called *Ward*, from whence the place and the government derive their name. The province of Bahus, though now yielded to the Swedes, is reckoned part of Norway, being a narrow track of land, about 90 miles in length, lying on the coast of the Categate.

The great chain of Norway mountains, running from north to south, called indifferently *Rudsfeld*, *Sudsfeld*, *Skarsfeld*, and *Scoreberg*, is known in different parts by other appellations; such as *Dofresfeld*, *Lamsfeld*, *Sagnefeld*, *Filefeld*, *Halnefeld*, *Hardangerfeld*, *Joklefeld*, *Byglefeld*, *Hicklefeld*, and *Hangfeld*. The height and breadth of this extensive chain likewise vary in different parts. To pass the mountain Hardanger, a man must travel about 70 English miles, whereas Filefeld may be about 50 over. This last rises about two miles and a half in perpendicular height; but Dofresfeld is counted the highest mountain of Norway, if not of Europe. The river Drivane winds along the side of it in a serpentine course, so as to be met nine times by those who travel the winter-road to the other side of the chain. The bridges are thrown over roaring cataracts, and but indifferently fastened to the steep rocks on either side; so that the whole exhibits a very dreadful appearance, sufficient to deter the traveller from hazarding such a dangerous passage; for which reason, people generally choose the road over Filefeld, which is much more tedious. This, however, is the post-road used by the king's carriages. The way is distinguished by posts fixed at the distance of 200 paces from each other, that, in snowy or dark weather, the traveller may not be bewildered.

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Norway. wildered. For the convenience of resting and refreshing, there are two mountain-stoves or houses maintained on Filefield, as well as upon other mountains, at the expence of the public, and furnished with fire, light, and kitchen-utensils. Nothing can be more dismal and dreary than these mountains covered with eternal snow, where neither house, tree, nor living creature is to be seen, but here and there a solitary rein-deer, and perchance a few wandering Laplanders.

In travelling from Sweden to Nordenfields, there is only one way of avoiding this chain of mountains; and that is, where it is interrupted by a long deep valley, extending from Romfdale to Guldbrandfdale. In the year 1612, a body of 1000 Scots, commanded by Sinclair, and sent over as auxiliaries to the Swedes, were put to the sword in this defile, by the peasants of Guldbrand, who never give quarter.

Besides this chain, there is a great number of detached mountains over all the country, that form valleys and ridges, inhabited by the peasants. Some of these are of incredible height, and others exhibit very remarkable appearances. In sailing up Joering Creek on the left hand, the sight is astonished with a groupe of mountains, resembling the prospect of a city, with old Gothic towers and edifices. In the parish of Oerfkong is the high mountain Skopshorn, the top of which represents the figure of a fortification, with regular walls and bastions. In the district of Hilgeland appears a very high range of mountains, with seven pinnacles or crests, known by the appellation of the *Seven Sisters*, discernible a great way off at sea. To the southward of this range, though in the same district, rises the famous mountain *Torgbatten*, so called because the summit resembles a man's head with a hat on, under which appears a single eye, formed by an aperture through the mountain, 150 ells high, and 3000 ells in length. The sun may be seen through this surprising cavity, which is passable by the foot of travellers. On the top of the mountain we find a reservoir of water, as large as a moderate fish-pond: in the lower part is a cavern, through which a line 400 fathoms in length, being let down, did not reach the bottom. At Herroe in Sundmoer is another cavern called *Dolfleen*, supposed to reach under the sea to Scotland; which, however, is no more than an idle tradition. In the year 1750, two clergymen entered this subterranean cavity, and proceeded a considerable way, until they heard the sea dashing over their heads: the passage was as wide and high as an ordinary church, the sides perpendicular, and the roof vaulted. They descended one flight of natural stairs; but arriving at another, they were afraid to penetrate farther: they had gone so far, however, that two candles were consumed in their progress and return. A cavern of a very curious nature, serving as a conduit to a stream of water, penetrates through the sides of the mountain Limur. In the district of Rake, in the neighbourhood of Frederickshall, are three cavities in a rock; one of which is so deep, that a small stone dropped down, does not reach the bottom in less than two minutes; and then the sound it produces is pleasant and melodious, not unlike the sound of a bell.

The vast mountains and rugged rocks that deform the face of this country are productive of numberless

inconveniences. They admit of little arable ground: they render the country in some parts impassable, and every where difficult to travellers: they afford shelter to wild beasts, which come from their lurking holes, and make terrible havock among the flocks of cattle: they expose the sheep and goats, as well as the peasant, to daily accidents of falling over precipices: they occasion sudden torrents, and falls of snow, which descend with incredible impetuosity, and often sweep away the labours of the husbandman; and they are subject to dreadful disruptions, by which huge rocks are rent from their sides, and, hurling down, overwhelm the plains below with inevitable ruin. The peasants frequently build their houses on the edge of a steep precipice, to which they must climb by ladders, at the hazard of their lives; and when a person dies, the corpse must be let down with ropes, before it can be laid in the coffin. In winter the mail is often drawn up the sides of steep mountains. Even in the king's road, travellers are exposed to the frequent risks of falling over those dreadful rocks; for they are obliged to pass over narrow pathways, without rails or rising on the sides, either shored up with rotten posts, or suspended by iron bolts fastened in the mountains. In the narrow pass of Naeroe is a remarkable way of this kind, which, above 600 years ago, the famous king Surre caused to be made for the passage of his cavalry; and even this would have been found impassable by any other horses than those of Norway, which are used to climb the rocks like goats. Another very difficult and dangerous road is that between Shogtadt and Vang in Volders, along the side of a steep mountain, in some places so narrow, that if two travellers on horseback should meet in the night, they would find it impracticable either to pass each other, or turn back. In such a case their lives could not be saved, unless one of them should alight, and throw his horse headlong into the lake below, and then cling to the rock, until the other could pass. When a sheep or goat makes a false step to the projection of a rock, from whence it can neither ascend nor descend, the owner hazards his own life to preserve that of the animal. He directs himself to be lowered down from the top of the mountain, sitting on a cross stick, tied to the end of a long rope; and when he arrives at the place where the creature stands, he fastens it to the same cord, and it is drawn up with himself. Perhaps the other end of the rope is held by one person only; and there are some instances in which the assistant has been dragged down by the weight of his friend, so that both have perished. When either man or beast has had the misfortune to fall over very high precipices, they have not only been suffocated by the repercussion of the air, but their bodies have been always burst before they reached the ground. Sometimes entire crests of rocks, many fathoms in length and breadth, have fallen down at once, creating such a violent agitation of the air, as seemed a prelude to the world's dissolution. At Steenbroe in Laerdale, a stupendous mass, larger than any castle in the universe, appears to have been severed and tumbled from the mountain in large, sharp, and ragged fragments, through which the river roars with hideous bellowing. In the year 1731, a promontory on Sundmoer, called *Rammersfield*, that hung

Norway.

Norway. hung over Nordal Creek, suddenly gave way, and plunged into the water; which swelled to such a degree, that the church of Strand, tho' half a league on the other side of the bank, was overflowed: the creek, however, was not filled up; on the contrary, the fishermen declare they find no difference in the depth, which is said to exceed 900 fathoms.

The remarkable rivers of Norway are these: The Nied, issuing from Tydalen, on the borders of Sweden, runs westward into the lake Selboe; and afterwards, turning to the northward, passes by the city of Drontheim, to which it anciently gave the name of *Nideros* and *Nidrosia*: Sule Ely, that descending from Sulefield, runs with a rapid course thro' Nordale into the sea: Gulen, which rises near Sffarsfield in the north; and running 20 leagues westward, thro' Aalen, Hlotaalen, Storen, and Melhuus, discharges itself into the sea, about a league to the west of Drontheim. In the year 1344, this river buried itself under ground: from whence it again burst forth with such violence, that the earth and stones thrown up by the eruption filled the valley, and formed a dam; which, however, was soon broken and washed away by the force of the water. Divers churches, 48 farm-houses, with 250 persons, were destroyed on this occasion. Otteroen, a large river, taking its rise from the mountain Agde, runs about 30 leagues through Seeterdale and Esie, and disembogues itself into the cataract of Wiland. The river Syre rises near the mountain Lang, and winds its course thro' the vale of Syre into the lake of Lunde in the diocese of Christianland; thence it continues its way to the sea, into which it discharges itself through a narrow strait formed by two rocks. This contraction augments its impetuosity, so that it shoots like an arrow into the sea, in which it produces a very great agitation. Nid and Sheen are two considerable rivers, issuing out of Tillemark. Their water-falls have been diverted, with infinite labour, by canals and passages cut through the rocks, for the convenience of floating down the timber. Tyrefjord, or Dramme, is in the neighbourhood of Honifosse, joined by two rivers from Oedale and Hadeland, and disembogues itself into the sea near Bragnefs. Loven rises in the highest part of Nummedal, and runs through Konsberg to the sea near Laurwig. Glaamen is the largest river of Norway, distinguished by the name of *Stor Elvin*, or the great river. It derives its origin from the mountain Dofre, from whence it winds all along the plains of Oesterdale and Soloe; then joins the Vorme, another considerable river rising out of Miores and Guldbrandfdale. These being joined, traverse the lake Oeyeren; and thence issuing, run on to Sarp near Frederickstadt.

Norway abounds with fresh-water lakes; the principal of which are, Ryfvand in Nordland, Snaasen, Selboe, the Greater and Lesser Miores, Slirevand, Sperdille, Rand, Vestn, Saren, Modum, Lund, Norfoe, Huidfoe, Farisvand, and Oeyevand: all these are well stocked with fish, and navigable for large vessels. Wars have been formerly carried on upon these inland seas; in some of which are small floating islands, or parcels of earth, with trees on them, separated from the main land, and probably preserved in compact masses by the roots of trees, shrubs, and grass, interwoven in the soil. In the year 1702, the family-

seat of Borge, near Frederickstadt, being a noble edifice, with lofty towers and battlements, suddenly sunk into an abyss 100 fathoms deep, which was instantaneously filled by a piece of water 300 ells in length and about half as broad. Fourteen persons, with 200 head of cattle, perished in this catastrophe, which was occasioned by the river Glaamen precipitating itself down a water-fall near Sarp, and undermining the foundation. Of all the water-falls in Norway this of Sarp is the most dangerous for its height and rapidity. The current drives 17 mills; and roars with such violence, that the water, being dashed and comminuted among the rocks, rises in the form of rain, where a beautiful rainbow may be always seen when the sun shines. In ancient times this cataract was made use of for the execution of traitors and other malefactors: they were thrown down alive, that they might be dashed in pieces on the points of rocks, and die in a dreadful commotion, analogous to those they had endeavoured to excite in the community.

Great part of Norway is covered with forests of wood, which constitute the principal article of commerce in this country. They chiefly consist of fir and pine, for which great sums are received from foreigners, who export an immense number of masts, beams, planks, and boards. Besides, an incredible quantity is consumed at home, in building houses, ships, bridges, piles, moles, and fences; over and above the vast demand for charcoal to the founderies, and fuel for domestic uses. Nay, in some places, the trees are felled for no other purpose but to clear the ground and to be burned into ashes for manure. A good quantity of timber is yearly exported to Scotland and Spain: but this is inconsiderable when compared to the vast exports from Drammen, Frederickshall or Frederickstadt, Christiania, Skeen, Arendal, Christianland, Christian's-bay, and Drontheim. The masts and large beams are floated down the rivers, and the rest is divided into boards at the saw-mills. These works supply a vast number of families with a comfortable subsistence. A tenth part of all sawed timber belongs to his Danish majesty, and makes a considerable branch of his revenue. The forests in Norway are so vast and thick, that the people seem to think there can never be a scarcity of wood, especially as the soil is peculiarly adapted for the production of timber: they therefore destroy it with a wasteful hand; inasmuch that more wood rots in Norway than is burned in the whole kingdom of Denmark. The best timber grows in the provinces of Saltan, Helleland, Romfdale, Guldbrandfdale, Oesterdale, Soloe, Valdars, Hallingdale, Sognifjord, Tellemark, and the lordship of Nedene.

The climate of Norway is very different in different parts of the kingdom. At Bergen the winter is so moderate, that the seas are always open and practicable both to mariners and fishermen, except in creeks and bays, that reach far up into the country towards Filefield, when the keen north-east wind blows from the land. On the east side of Norway from the frontiers of Sweden to Filefield, the cold generally sets in about the middle of October with great severity, and lasts till the middle of April; during which interval the waters are frozen to a very

Norway. considerable thickness, and the face of the country is covered with snow. In the year 1719, 7500 Swedes, who intended to attack Drontheim, perished in the snow on the mountain of Ruden or Tydel, which separates Jemteland in Sweden from the diocese of Drontheim. A company of 200 Norwegian sledge-men under major Emahus, found them all frozen to death on the ridge of the mountain, where they had been surprised by a storm accompanied with snow, hail, and extreme cold. Some of these unhappy victims appeared sitting, some lying, and others kneeling in a posture of praying. They had cut in pieces their muskets, and burned the little wood they afforded. The generals Labarre and Zoega lost their lives; and of the whole corps, consisting originally of 10,000, no more than 2500 survived this dreadful catastrophe.

The cold is still more intense in that part of Norway called *Finmark*, situated in the frigid zone near the polar circle. But if the winter is generally cold, the summer is often excessively hot, in Norway. The rays of the sun are reverberated from the sides of the mountains so as to render the weather close and sultry in the valleys; besides, the sun's absence below the horizon is so short, that the atmosphere and mountains have not time to cool. The heat is so great, that vegetation is remarkably quick. Barley is sown, grows, ripens, and is reaped, in the space of six weeks or two months.—The longest day at Bergen consists of 19 hours; the sun rising at half an hour after two, and setting at half an hour after nine. The shortest day does not exceed six hours; for the sun rises at nine in the morning, and sets at three in the afternoon. In the beginning of the year the daylight increases with remarkable celerity; and, at the approach of winter, decreases in the same proportion. In summer one may read and write at midnight by the light of the sky. Christian V. while he resided at Drontheim, used to sup at midnight without candles. In the district of Tromsen, at the extremity of Norway, the sun is continually in view at midsummer. It is seen to circulate day and night round the north pole, contracting its orbit, and then gradually enlarging it, until at length it leaves the horizon. In the depth of winter, therefore, it is for some weeks invisible; and all the light perceived at noon is a faint glimmering for about an hour and an half, proceeding from the reflection of the sun's rays from the highest mountains. But the inhabitants of these provinces are supplied with other lights that enable them to follow their employments in the open air. The sky being generally serene, the moonshine is remarkably bright, and, being reflected from the mountains, illuminates the valleys. They are also assisted by the *Aurora Borealis*, which is very frequent in the northern parts of Europe.

The air of Norway is generally pure and salubrious. On the sea-coasts, indeed, it is rendered moist by vapours and exhalations: but in the midland parts of the country, towards the mountains, the climate is so dry, that meal may be kept for many years without being worm-eaten or damaged in the least. The inhabitants have no idea of sickness, except what is occasioned by excesses. It is said, that in the vale of Guldbrand the inhabitants live to such extreme old age, that they become weary of life, and cause themselves to be re-

moved to a less salubrious climate, whereby they may have a chance of dying the sooner. In consumptions, however, the moist air on the sea-side is found to be most agreeable to the lungs in respiration. Norway, being a mountainous country intersected by creeks, abounding with lakes, rivers, and snow, must be subject to frequent rains; and from sudden thaws the inhabitants are sometimes exposed to terrible disasters. Vast masses of snow falling from precipices, overwhelm men, cattle, boats, houses, nay even whole villages. About two centuries ago, a whole parish was covered and destroyed by an immense mass of snow; and several domestic utensils, as scissars, knives, and basons, have been at different times brought to light by a rivulet that runs under the snow, which has been gradually hardened and increased by repeated frosts and annual accessions.

The winds that chiefly prevail on the western coast are those that blow from the south; whereas, on the other side of Filefield, the winds that produce and continue the hard frosts are always northerly. In the summer, there is a kind of regular trade-wind on the coast of Bergen. In the forenoon the sea begins to be cooled with a westerly breeze, which continues till midnight. Then the land breeze begins from the east, and blows till about ten in the morning. The coast is likewise subject to sudden squalls and storms. Hurricanes sometimes rise at sea; and in these latitudes the phenomenon called a *water-spout* is not uncommon. One of these in the neighbourhood of Ferro is said to have sucked up with the water some lasts of herrings, which were afterwards dropped on Kolter, a mountain 1200 feet high.

The fresh-water of Norway is not very light or pure; but on the contrary is generally turbid, and deposits a sediment of adventitious matter, being sometimes impregnated with ochre, and particles of iron. Nevertheless it is agreeable to the taste, and remarkably salubrious; as appears from the good health of the common people, who drink little or no other liquor.

The soil of Norway varies in different places according to the situation of rock or valley. The mountains here, as in every other country, are bare and barren; but the earth washed down from them by the rains enriches and fertilizes the valleys. In these the soil generally consists of black mould, sand, loam, chalk, and gravel, lying over one another in unequal strata, and sometimes in three or four successions: the mould that lies uppermost is very fine and mellow, and fit to nourish all sorts of vegetables. There is also clay found in different parts of this kingdom, of which the inhabitants begin to make earthen ware; but bricks and tiles are not used in building. The face of the country is in many places deformed by large swamps and marshes, very dangerous to the traveller. Near Leeffoe in the diocese of Christianland, a wooden causeway is extended near a mile over a morass; and if a horse or any other animal should make a false step, he will sink at once into the abyss, never to rise again.

In a cold country like Norway, roughened with rocks and mountains, interspersed with bogs, and covered with forests, we cannot expect to find agriculture in perfection. The ploughed lands, in respect to mountains, woods, meadows, and wastes, do not exceed the

Norway. the proportion of 1 to 80; so that the whole country does not produce corn to maintain above half the number of its inhabitants. The peasants are discouraged from the practice of husbandry by the frequency of accidents that seem peculiar to the climate. Even in the fruitful provinces of Guldbrandsdale, Oesterdale, and Soloer, as well as in other places, when the corn appears in the most flourishing condition, the whole hope of the harvest is sometimes destroyed in one night by a sudden frost that nips the blade and extinguishes the vegetation. The kingdom is moreover visited by some unfavourable years, in which the sun seems to have lost his genial power; the vegetables are stunted; the trees bud and bloom, yet bear no fruit; and the grain, though it rises, will yet produce nothing but empty ears and straw. This calamity, however, rarely occurs; and in general the cultivated parts of Norway yield plentiful crops of excellent rye, barley, and oats. The most fruitful provinces are Nordland, Inderbarre, and Numedale, in the diocese of Drontheim; Sognifjord and Vaas, in that of Bergen; Jedderen, Ryefylsk, Raabygdalag, and the lordship of Nedenes, in the diocese of Christiansand; Hedemark in the diocese of Aggerhuis; Hadeland, Toten, Romerige, Ringerige, and Guldbrandsdale: these territories not only produce grain enough for their own consumption, but likewise support their neighbours, and even supply part of Sweden. Pease are likewise propagated in this country, together with wheat, buck-wheat, hops, hemp and flax, but not to any considerable advantage. The meadows are well stored with pasturage for sheep and cattle, and the fields are productive of those vegetables which are common in other northern countries. Within these 50 years the people of Norway have bestowed some attention on the culture of gardens, which in former times was so neglected, that the cities and towns were supplied with leeks, cabbage, and roots, from England and Holland. At present, however, the Norwegians raise their own culinary and garden roots and vegetables, which thrive there as well as in any other country. The scurvy being a disease that prevails along the sea-coast, Nature has scattered upon it a variety of herbs efficacious in the cure of that distemper; such as angelica, rose-wort, gentian, cresses, trefoil, sorrel, scurvy-grass, and a plant called *erich's grass*, that grows in great plenty on the islands of Northland: from whence the people of the continent fetch away boat-loads of it, to be preserved in barrels as a succedaneum for cabbage. There are also a few noxious vegetables little known in any country but Norway. In Guldbrandsdale is a species of grass called *selfnape*; the root of which is so poisonous, that any beast which eats of it dies immediately, the belly bursting; nay, the carnivorous fowls that prey upon the carcase of the beast meet with the same fate: children have been more than once poisoned by this root, which nevertheless is sometimes used externally as an amulet for arthritic disorders. Another vegetable pernicious to the cattle is the *Gramen ossifragum Norwegiense*, which is said to mollify the bones of the cattle which feed upon it. Among the noxious plants of Norway we may also reckon the igle-grass, fatal to sheep and goats; the tour-grass, which affects horses and cows with a sort of lethargy; and the plant

Norway. torboe, or hifte-spring, which produces nearly the same effect on horses, but is not at all prejudicial to cows, sheep, or any ruminating animals. The herb turte, not unlike angelica, operates nearly in the same manner: yet the bears are said to feed upon it with peculiar relish; and when their hair begins to fall off by feeding upon this plant, they cure themselves by eating the flesh of animals.

The common fruit-trees thrive tolerably well in Norway, the inhabitants of which have plenty of cherries, apples, and pears. Some kinds of plums attain maturity; which is seldom the case with grapes, apricots, and peaches. But even the apples and pears that ripen here are summer-fruit; that which grows till the winter seldom coming to perfection. Great variety of agreeable berries are produced in different parts of this kingdom; such as the hagebar, a kind of sloe; an infusion of which in wine makes a pleasant cooling liquor; juniper berries, corinths red and white, foelbar or sun-berries, raspberries, gooseberries, blackberries, strawberries, &c. with many other species that seem to be natives of Norway and Sweden. Among those are the tranæbar, the produce of the myrtillus repens, red and austere, found in the spring in perfection under the snow, and much relished by the reindeer; crakebeer, resembling bilberries, deemed a powerful antiscorbutic; agerbeer, larger and blacker than bilberries, of a pleasant acid, ripened by cold, and used as cherries for an infusion in wine; and finally tylte-beer, a red pleasant berry growing on a short stem, with leaves like those of box: they are plucked off by handfuls, and sent to Denmark to be preserved for the table, where they are eaten by way of desert.

Of the trees that grow wild in Norway, the principal are the fir and the pine. The first yield an annual revenue of 1,000,000 of rix-dollars, if we include the advantages resulting from the saw-mills and the masts; one of which last has been known to sell for 200 rix-dollars. The red fir-tree, which grows on the mountains, is so rich in turpentine as to be almost incorruptible. Some of the houses belonging to the Norway peasants, built of this timber, are supposed to be above 400 years standing. In Guldbrandsdale the house is still to be seen standing in which king Olaf lodged five nights, above 700 years ago, when he travelled round the kingdom to convert the people to the Christian faith. Even 100 years after the trunk of the fir-tree has been cut down, the peasants burn the roots for tar, which is a very profitable commodity. In the fens, the resin of the fir-tree is by nature transformed into a substance which may be called *Norway frankincense*. The buds or pine-apples of this tree, boiled in stale beer, make an excellent medicine for the scurvy; less unpleasant to the taste, though as efficacious, as tar-water. The pine-tree is more tall and beautiful than the fir, though inferior to it in strength and quality: for which reason the planks of it are sold at an inferior price, and the peasants waste it without remorse. Norway likewise produces some forests of oak, which is found to be excellent for ship-building. Here also grow plenty of elm-trees; the bark of which, being powdered, is boiled up with other food to fatten hogs, and even mixed by the poor among their meal: also the ash, from which the peasants distil a balsam used in certain

Norway. certain disorders, and which is used both externally and internally. Many other trees flourish in this country, an enumeration of which would prove too tedious. Hazels grow here in such abundance, that 100 tons of the nuts are annually exported from Bergen alone.

A great diversity of stones is found in Norway, some of which are of a surprising figure. Several mountains consist chiefly of a brown pebble, which decays with age; nay, it sometimes dissolves, and drops into the sea, and the cement being thus loosened, a terrible disruption ensues. In some places the grey and black pebbles are intermixed with iron, copper, lead, silver, and gold. The ground in certain districts is covered with the fragments of rocks that have been precipitated from the summits of mountains, and broken by their fall into innumerable shivers. Between 20 and 30 years ago, in the neighbourhood of Bergen, a man was suddenly overwhelmed with such a mass, which formed a kind of vault around him. In this dreadful tomb he remained alive for several weeks. By his loud cries the place of his confinement was discovered: but it was found impossible to remove the huge stones by which he was inclosed. All that his friends could do for him was, to lower down meat and drink through some crevices; but at length the stones fell in, and crushed him to death.

In Norway are inexhaustible quarries of excellent marble, black, white, blue, grey, and variegated; together with some detached pieces of alabaster, several kinds of spar, chalk-stone, cement-stone, sand-stone, mill-stone, baking-stone, slate, talc, magnets; and swine-stone, a production natural to Norway and Sweden, of a brown colour, fetid smell, in texture resembling crystal, and deriving its name from a supposed efficacy in curing a distemper incident to swine. Here also is found the amianthus or stone-flax, of which incom-bustible cloth may be made. Norway, however, affords no flints, but plenty of pyrites or quartz, beautiful crystals, granites, amethysts, agate, thunder-stones, and eagle-stones. Gold has formerly been found in a small quantity in the diocese of Christian-sand, and coined into ducats. There is at present a very considerable silver-mine wrought at Kongsberg on the account and at the risk of his Danish majesty: the ore is surprisingly rich, but interrupted in such a manner, that the vein is often lost. Many masses of pure silver have been found; and, among the rest, one piece weighing 560 pounds, preserved in the royal museum at Copenhagen. Such is the richness of these mines, that the annual produce amounts in value to a ton and an half in gold. About 5000 people are daily employed, and earn their subsistence, in those stupendous works (A). Other silver-mines are prosecuted at Jarlsberg, but not to the same advantage; and here the ore is mixed with lead and copper. In many parts of this

Norway. country copper-mines have been discovered; but the principal, and perhaps the richest in all Europe, is at Roraas, about 100 English miles from Drontheim. This work yields annually about 1100 ship-pounds of pure copper: the founderies belonging to it consume yearly about 14,000 lasts of coal, and 500 fathoms of wood. The next in importance is the copper-work at Lykken, about 20 miles from Drontheim. A third mine is carried on at Indset, or Quickne, at the distance of 30 miles from the same place; and here they precipitate the copper from its menstruum, by means of iron. There is a fourth copper-work at Silboe, about 30 miles distant from Drontheim, though the least considerable of the four. Other copper-mines of less note are worked in different parts of the kingdom. Iron is still in greater plenty, and was the first metal wrought in this country. Many hundred thousand quintals are annually exported, chiefly in bars, and part of it in stoves, pots, kettles, and cannon: the national profit arising from this metal is estimated at 300,000 rix dollars. There is a species called *moor-iron*, found in large lumps among the morasses: of this the peasants make their own domestic tools and utensils, such as knives, scythes, and axes. The lead found mixed in the silver-ore is an article of small importance in Norway; yet some mines of this metal have been lately opened in the district of Soloer by the proprietors of the copper-work at Oudal. A vitriol-work has been begun near Kongsberg: the mines yield great plenty of sulphur; which, however, the Norwegians will not take the trouble to melt and depurate, because immense quantities are found at a cheaper rate in the island of Iceland. Alum is found between the slate flakes near Christiana in such plenty, that works have been set up for refining this mineral, though they have not yet brought it to any degree of transparency. His Danish majesty has established salt-works in the peninsula of Valoe, about six English miles from Tonsberg, where this mineral is extracted in large quantities from the sea-water.

Besides the animals common to other countries, Norway is said to contain many of the uncommon and dubious kind; such as the kraken, mermaid, sea-serpent, &c. See these articles.

Many Danish, English, Scotch, Dutch, and German, families have now settled in Norway; and indeed form no inconsiderable part of the trading people: but the original inhabitants are the descendants of those ferocious Normanni, who harassed almost all the coasts of Europe with piratical armaments in the 8th, 9th, and 10th centuries.

"Our first certain knowledge of the inhabitants of this country (says Pennant†) was from the desolation they brought on the southern nations by their piratical invasions. Their country had before that period the name of *Nortmannaland*, and the inhabitants

(A) Mr Coxe tells us, that he visited those mines. They formerly, he says, produced annually L. 70,000, but at present yield little more than L. 50,000. The expences generally exceed the profits; and government gains only by the number of miners employed. The mines of cobalt, and the preparation of Prussian blue, are much more productive. The latter goes through 270 hands, and the number of men employed are 356. It is supposed, that, at this period (1793), it may produce to government a profit of L. 16,000 a-year.

Norway. tants *Nortmans*; a title which included other adjacent people. Great Britain and Ireland were ravaged by them in 845; and they continued their invasion till they effected the conquest of England, under their leader Canute the Great. They went up the Seine as far as Paris, burnt the town, and forced its weak monarch to purchase their absence at the price of fourteen thousand marks. They plundered Spain, and at length carried their excursions through the Mediterranean to Italy, and even into Sicily. They used narrow vessels, like their ancestors the Sitones; and, besides oars, added the improvement of two sails; and victualled them with salted provisions, biscuit, cheese, and beer. Their ships were at first small; but in after times they were large enough to hold 100 or 120 men. But the multitude of vessels was amazing. The fleet of Harold Blaatand consisted of 700. A hundred thousand of these savages have at once sailed from Scandinavia, so justly styled *Officina gentium, aut certe velut vagina nationum*. Probably necessity, more than ambition, caused them to discharge their country of its exuberant numbers. Multitudes were destroyed; but multitudes remained, and peopled more favourable climates.

"Their king, Olaus, was a convert to Christianity in 994; Bernard an Englishman had the honour of baptizing him, when Olaus happened to touch at one of the Scilly islands. He plundered with great spirit during several years; and in 1006 received the crown of martyrdom from his pagan subjects. But religious zeal first gave the rest of Europe a knowledge of their country and the sweets of its commerce. The Hanse towns poured in their missionaries, and reaped a temporal harvest. By the year 1204, the merchants obtained from the wise prince Suer every encouragement to commerce; and by that means introduced wealth and civilization into his barren kingdom. England by every method cherished the advantages resulting from an intercourse with Norway, and Bergen was the emporium. Henry III. in 1217, entered into a league with its monarch Haquin; by which both princes stipulated for free access for their subjects into their respective kingdoms, free trade, and security to their persons. In 1269, Henry entered into another treaty with Magnus; in which it was agreed, that no goods should be exported from either kingdom except they had been paid for; and there is, besides, a humane provision on both sides, for the security of the persons and effects of the subjects who should suffer shipwreck on their several coasts."

The inhabitants now speak the same language that is used in Denmark, though their original tongue is the dialect now spoken in Iceland. They profess the Lutheran religion, under an archbishop established at Drontheim, with four suffragans; namely, of Bergen, Staffanger, Hammer, and Christiana. By the union of Calmar, the two kingdoms of Norway and Denmark were united under one monarch; and then the people of both nations enjoyed considerable privileges: but the Danish government soon became absolute; and Norway was ruled despotically by a viceroy, who resided in the capital, and presided in the supreme court, to which appeals were made from the subordinate courts of judicature. A great change has,

Norway. however, taken place since the present amiable and accomplished prince of Denmark had part of the government, and more may be expected from his virtue and assiduity when the power shall come wholly into his own hands.

The Norwegians are generally well-formed, tall, sturdy, and robust, brave, hardy, honest, hospitable, and ingenious; yet savage, rash, quarrelsome, and litigious. The same character will nearly suit the inhabitants of every mountainous country in the northern climates. Their women are well-shaped, tall, comely, remarkably fair, and obliging. The nobility of Norway have been chiefly removed by the kings of Denmark, in order to prevent faction and opposition to the court; or are long ago degenerated into the rank of peasants: some families, however, have been lately raised to that dignity. Every freeholder in Norway enjoys the right of primogeniture and power of redemption; and it is very usual to see a peasant inhabiting the same house which has been possessed 400 years by his ancestors. The *odels gads*, or freehold, cannot be alienated by sale or otherwise from the right heir, called *odels-mand*: if he is not able to redeem the estate, he declares his incapacity every 10th year at the sessions; and if he, or his heirs to the third generation, should acquire wealth enough for that purpose, the possessor *pro tempore* must resign his possession.

The mountaineers acquire surprising strength and dexterity by hard living, cold, laborious exercise, climbing rocks, skating on the snow, and handling arms, which they carry from their youth to defend themselves against the wild beasts of the forest. Those who dwell in the maritime parts of Norway exercise the employments of fishing and navigation, and become very expert mariners.

The peasants of Norway never employ any handicraftsmen for necessities to themselves and families: they are their own hatters, shoemakers, tanners, weavers, carpenters, smiths, and joiners: they are even expert at ship-building; and some of them make excellent violins. But their general turn is for carving in wood, which they execute in a surprising manner with a common knife of their own forging. They are taught in their youth to wrestle, ride, swim, skate, climb, shoot, and forge iron. Their amusements consist in making verses, blowing the horn, or playing upon a kind of guitar, and the violin: this last kind of music they perform even at funerals. The Norwegians have evinced their valour and fidelity in a thousand different instances. The country was always distracted by intestine quarrels, which raged from generation to generation. Even the farmers stand upon their punctilio, and challenge one another to single combat with their knives. On such occasions they hook themselves together by their belts, and fight until one of them is killed or mortally wounded. At weddings and public feasts they drink to intoxication, quarrel, fight, and murder generally ensues. The very common people are likewise passionate, ambitious of glory and independence, and vain of their pedigree. The nobility and merchants of Norway fare sumptuously; but the peasant lives with the utmost temperance and frugality, except at festivals.

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festivals: his common bread is made of oatmeal, rolled into broad thin cakes, like those used in Scotland. In time of scarcity, they boil, dry, and grind the bark of the fir-tree into a kind of flour which they mix with oat-meal: the bark of the elm-tree is used in the same manner. In those parts where a fishery is carried on, they knead the roes of cod with their oat-meal. Of these last, mixed with barley-meal, they make hasty-pudding and soup, enriched with a pickled herring or salted mackarel. Fresh fish they have in plenty on the sea-coast. They hunt and eat grouse, partridge, hare, red deer, and rein-deer. They kill cows, sheep, and goats, for their winter stock: these they pickle, or smoke, or dry for use. They make cheese of their milk, and a liquor called *fyre* of their four whey: this they commonly drink mixed with water; but they provide a store of strong ale for Christmas, weddings, christenings, and other entertainments. From their temperance and exercise, joined to the purity and elasticity of their air, they enjoy good health, and often attain to a surprising degree of longevity. Nothing is more common than to see a hearty Norwegian turned of 100. In the year 1733, four couples danced before his Danish majesty at Fredericks-hall: their ages, when joined, exceeded 800 years. Nevertheless, the Norwegians are subject to various diseases; such as the scab, the leprosy, the scurvy, the catarrh, the rheumatism, gout, and epilepsy. The dress of the Norway peasants consists of a wide loose jacket made of coarse cloath, with waistcoat and breeches of the same. Their heads are covered with flapped hats, or caps ornamented with ribbons. They wear shoes without outer soles, and in the winter leathern buskins. They have likewise snow-shoes and long skates, with which they travel at a great pace, either on the land or ice. There is a corps of soldiers thus accoutred, who can out-march the swiftest horses. The Norwegian peasant never wears a neckcloth, except on extraordinary occasions: he opens his neck and breast to the weather, and lets the snow beat into his bosom. His body is girt round with a broad leathern belt, adorned with brass plates, from which depends a brass chain that sustains a large knife, gimlet, and other tackle. The women are dressed in close-laced jackets, having leathern girdles decorated with ornaments of silver. They likewise wear silver chains round their necks, to the ends of which are fixed gilt medals. Their caps and handkerchiefs are almost covered with small plates of silver, brass, and tin, large rings, and buttons. A maiden bride appears with her hair plaited, and, together with her cloaths, hung full of such jingling trinkets.

The churches, public edifices, and many private houses in Norway, are built of stone: but the people in general live in wooden houses, made of the trunks of fir and pine-tree laid upon each other, and joined by mortises at the corners. These are counted more dry, warm, and healthy, than stone or brick buildings. In the whole diocese of Bergen, one hardly sees a farm-house with a chimney or window: they are generally lighted by a square hole in the top of the house, which lets in the light, and lets out the smoke. In summer this hole is left quite open: in the winter, it is covered with what they call a *fiou*; that is,

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the membrane of some animal, stretched upon a wooden frame that fits the hole, and transmits the rays of light. It is fixed or removed with a long pole occasionally. Every person that enters the house, upon business or courtship, takes hold of this pole, according to ancient custom. The ceiling is about eight feet high in the middle; and, being arched like a cupola, the smoke of the fire underneath rolls about, until it finds a vent at the hole, which is called *liur*. Under this opening stands a thick table with benches, and an high seat at the upper end for the master of the family: he has likewise a small cupboard for his own use, in which he locks up his most valuable effects. The boards of the roof are coated with the bark of birch-trees, which is counted incorruptible: this again is covered with turf, which yields a good crop of grass for goats and sheep, and is often mowed as hay by the farmer.

The Norwegians carry on a considerable trade with foreign nations. The duty on the produce of their own country exported, amounts annually to 100,000 rix-dollars. These commodities are, copper wrought and unwrought; iron cast into cannon, stoves, and pots, or forged into bars; lead, in small quantity; masts, timber, deal-boards, planks, marble, mill-stones, herring, cod, ling, salmon, lobsters, flounders, cow-hides, goat-skins, seal-skins, the furs of bears, wolves, foxes, beavers, ermines, martens, &c. down, feathers, butter, tallow, train-oil, tar, juniper and other sorts of berries, and nuts; salt, alum, glass, vitriol, and pot-ashes. All other commodities and articles of luxury the Norwegians import from different nations. The nature of the ground does not admit of much improvement in agriculture: nevertheless, the farmers are not deficient in industry and skill to drain marshes, and render the ground arable and fit for pasture. Many are employed in grazing and breeding cattle: but a much greater number is engaged in felling wood, floating timber, burning charcoal, and extracting tar from the roots of the trees which have been cut down; in the silver, copper, and iron-mines; in the navigation and fishery. A considerable number of people earn a comfortable livelihood by hunting, shooting, and bird-catching. Every individual is at liberty to pursue the game, especially in the mountains and commons: therefore every peasant is expert in the use of fire-arms; and there are excellent marksmen among the mountains, who make use of the bow to kill those animals, whose skins, being valuable, would be damaged by the shot of fire-arms.

Norway can produce above 14,000 excellent seamen. The army of this country amounts to 30,000 effective men; and the annual revenue exceeds 800,000 rix-dollars.

NORWAY-Rat, in zoology. See Mus.

NORWICH, the capital of the county of Norfolk in England, situated in E. Long. 1. 26. N. Lat. 52. 40. It is supposed to have had its name, which signifies "a castle to the north," from its situation in respect of Caistor, the ancient Venta Icenorum, three or four miles to the south of it, out of whose ruins it seems to have risen. In its infancy, in the reign of Etheldred, it was plundered and burnt by Sueno the Dane, when he invaded England with a great army. Afterwards it recovered; and in the reign of Edward the

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the Confessor was a considerable place, having 1320 burghers. But it suffered again much in the reign of William I. by being the seat of a civil war, which Ralph earl of the East Angles raised against that king. So much was it impaired by the siege it then underwent, that there were scarce 560 burghers left in it, as appears from Doomsday-book. From that time forward it began by little and little to recover, especially after Bishop Herbert translated the episcopal see hither from Thetford in the reign of William Rufus in 1096; and built a beautiful cathedral, of which he himself laid the first stone, with this inscription, *Dominus Herbertus posuit primum lapidem, in nomine Patris, Filii, & Spiritus Sancti, Amen, i. e.* "Lord (Bishop) Herbert laid the first stone, in the name of the Father, Son, and Holy Ghost;" and by a licence from Pope Paschal, declared it the mother-church of Norfolk and Suffolk. After this, as Malmshury has it, it became a town famous for merchandize and the number of inhabitants. Yet it was miserably harassed in the reign of Henry II. by Hugh Bigod earl of Norfolk, who was an adherent of Henry's son, called the *junior king*. In the time of Edward I. it was walled round by the citizens, who had presented a petition to parliament for liberty to do it. Henry IV. allowed them, instead of bailiffs, which they had before, to elect a mayor yearly, and made the city a county of itself. In the year 1348, near 58,000 persons were carried off by the plague; and in 1505, the city was almost consumed by fire. For the flourishing state to which the city is now arrived, they are much indebted to the Flemings, who fled hither from the tyranny of the duke of Alva and the inquisition, and taught them the manufacture of those striped and flowered damasks, camblets, druggets, black and white crape, for which the place is now so noted, and which have been computed to yield sometimes 200,000*l.* a-year. In the year 1583, the citizens, by the help of an engine, conveyed water through pipes to the highest parts of the city, which is pleasantly seated along the side of a hill, extending a mile and a half in length from north to south; but the breadth is much less, and it contracts itself by degrees towards the south. It is now one of the most considerable cities in Britain for wealth, populousness, neat buildings, beautiful churches (of which it had once 58, but now only 36), and the industry and civility of the inhabitants. The cathedral is a very venerable structure, with a curious roof, adorned with the history of the Bible in little images, carved to the life, and a lofty steeple 105 yards high. The wall of flint stone, beautified with 40 towers and 12 gates, finished in 1309, is now much decayed. The city, though there is a great deal of waste ground within the walls, was computed, about 60 years ago, to contain 8000 houses and 50,000 inhabitants. Besides the cathedral already mentioned, the most remarkable buildings are, the duke of Norfolk's house, one of the largest in England; the castle, which is now the county-gaol, and stands in the heart of the city, with a deep moat round it, over which is a bridge of one very large arch; the Town-hall; the Guild-hall, formerly the church belonging to the monastery of Black-Friars; the house of correction; the Shire-house, where the assizes are held; a lofty mar-

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ket-cross, built after the manner of a piazza; the bishop's palace; the king's school, founded by Edward VI. the boys of which are nominated by the mayor for the time being, with the consent of the majority of aldermen. There having been formerly many thatched houses, an order was made, that all houses that should hereafter be built should be covered with tiles. The city is interspersed with gardens, orchards, and trees, which make it both pleasant and healthful. It has four hospitals, in which a great number of old men and women, boys and girls, are maintained; and a dozen charity-schools. Here are two churches for the Dutch and French Flemings; who have particular privileges, and are very numerous. Some of the churches are thatched, and all of them crusted with flint stone curiously cut; which is the more wonderful, as Norwich stands in a clay country, and has no flint within 20 miles of it. It is now governed by a mayor, recorder, steward, two sheriffs, 24 aldermen, 60 common-council, with a town-clerk, sword-bearer, and other inferior officers. The mayor is chosen on May-day by the freemen, and sworn in on the Tuesday before Midsummer-eve. The sheriffs are also chosen annually, on the first Tuesday in August, one by the freemen, the other by the aldermen, and sworn in on Michaelmas-day. The freemen of the several wards choose each their alderman. The common-council is chosen in Midlent. The mayor is a justice of the peace and quorum, during his year (as are also the recorder and steward) within the city and liberties; and after his mayoralty, he is a justice during life. The trade and manufactures of the city are very considerable. At Yarmouth they export large quantities of their manufactures, most of which are sent to London, and import a great deal of wine, coal, fish, oil, &c. All the city and country round are employed in the worsted manufacture, brought hither, as already observed, by the Flemings, in which they not only consume the wool of their own county, in spinning, weaving, &c. but use many thousand packs of yarn, which they receive from other parts of England, as far as Yorkshire and Westmoreland. There are eight wardens of the weavers chosen annually, and sworn to take care that there be no frauds committed in spinning, weaving, or dying the stuffs. It is computed that there are not less than 120,000 people employed in and about the city in the silk and woollen manufactures. Their markets are thought to be the greatest in England, and furnished with a surprising plenty and variety of goods and provisions. At a small village to the north of the city, called *St Faith's*, not less than 40,000 head of Scotch cattle are said to be yearly bought up by the Norfolk graziers, and fattened in their meadows and marshes. Its markets are on Wednesday, Friday, and Saturday. It has a great number of fairs, sends two members to parliament, and gives the title of earl to the duke of Gordon.

Few cities or towns seem to have suffered more than Norwich has done at various periods, and few seem to have felt it less; for tho' quite burnt down by Sueno as above, it was of considerable consequence in Edward the Confessor's time: nor did it long feel the evils of the insurrection and siege in William the Conqueror's time, for it was rebuilt in Stephen's reign, and made a corporation; besides other devastations already mentioned.

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The city of Norwich has long been famous for its manufactures; which are not, in the opinion of some, at present in so flourishing a state as formerly. In addition to the manufacture of camblets, druggets, and crapes, it is also remarkable for baize, serges, shal-loons, stockings, and woollen cloths.

The inhabitants of Norwich are generally so employed in their manufactures within doors, that the city has the appearance of being deserted, except on Sundays and holidays, when the streets swarm with people.

Castor, near Norwich, was the Venta Icenorum, or capital city of the Iceni, the broken walls of which contain a square of about 30 acres. In those walls may still be perceived the remains of four gates and a tower. Several Roman urns, coins, and other relics of antiquity, have been found at this place.

NOSE, the organ of smell. See ANATOMY, n^o 140. The uses of the nose are, its giving us the sense of smelling; its serving in the great office of respiration, and in modelling the voice; in receiving the abundant humours from the eyes, and in adding to the beauty of the face.

The nose was by the Augurs particularly attended to in forming conjectures concerning future good or ill success. The tingling of the right or left side of it, for instance, was thought to have different significations as it happened to different sexes, or persons in different conditions.

In Tartary, the greatest beauties are those who have the least noses. Ruybroek mentions the wife of the great Jenghiz Khan as a celebrated beauty, because she had only two holes for a nose. The Crim-Tartars break the noses of their children while young, as thinking it a great piece of folly to have their noses stand before their eyes. In most other countries, China excepted, great noses are an honour.

In what the beauty of the nose consists, different nations have different opinions: and the following reflections of Sir Joshua Reynolds on this subject, are perhaps the most philosophical account of the beauty of form that is to be found in any language. "I suppose (says Sir Joshua) it will be easily granted, that no man can judge whether any animal be beautiful in its kind, or deformed, who has seen only one of that species; that is as conclusive in regard to the human figure: so that if a man born blind was to recover his sight, and the most beautiful woman was brought before him, he could not determine whether she was handsome or not; nor, if the most beautiful and most deformed were produced, could he any better determine to which he should give the preference, having seen only those two. To distinguish beauty, then, implies the having seen many individuals of that species. If it is asked, how is more skill acquired by the observation of greater numbers? I answer, that, in consequence of having seen many, the power is acquired even without seeking after it, of distinguishing between accidental blemishes and excrescences, which are continually varying the surface of Nature's works, and the invariable general form which Nature most frequently produces, and always seems to intend in her productions.

"Thus amongst the blades of grass or leaves of the same tree, though no two can be found exactly alike,

yet the general form is invariable: a naturalist, before he chose one as a sample, would examine many, since, if he took the first that occurred, it might have, by accident or otherwise, such a form as that it would scarce be known to belong to that species; he selects, as the painter does, the most beautiful, that is, the most general form of nature.

"Every species of the animal as well as the vegetable creation may be said to have a fixed or determinate form, towards which nature is continually inclining, like various lines terminating in the centre; or it may be compared to pendulums vibrating in different directions over one central point; and as they all cross the centre, though only one passes through any other point, so it will be found that perfect beauty is oftener produced by nature than deformity; I do not mean than deformity in general, but than any one kind of deformity. To instance in a particular part of a feature: the line that forms the ridge of the nose is beautiful when it is straight; this then is the central form, which is oftener found than either concave, convex, or any other irregular form that shall be proposed. As we are then more accustomed to beauty than deformity, we may conclude that to be the reason why we approve and admire it, as we approve and admire customs and fashions of dress for no other reason than that we are used to them; so that though habit and custom cannot be said to be the cause of beauty, it is certainly the cause of our liking it: and I have no doubt, but that if we were more used to deformity than beauty, deformity would then lose the idea now annexed to it, and take that of beauty; as if the whole world should agree that *yes* and *no* should change their meanings, *yes* would then deny, and *no* would affirm.

"Whoever undertakes to proceed further in this argument, and endeavours to fix a general criterion of beauty respecting different species, or to show why one species is more beautiful than another, it will be required from him first to prove that one species is really more beautiful than another. That we prefer one to the other, and with very good reason, will be readily granted; but it does not follow from thence that we think it a more beautiful form; for we have no criterion of form by which to determine our judgment. He who says a swan is more beautiful than a dove, means little more than that he has more pleasure in seeing a swan than a dove, either from the stateliness of its motions, or its being a more rare bird; and he who gives the preference to the dove, does it from some association of ideas of innocence that he always annexes to the dove: but if he pretends to defend the preference he gives to one or the other, by endeavouring to prove that this more beautiful form proceeds from a particular gradation of magnitude, undulation of a curve, or direction of a line, or whatever other conceit of his imagination he shall fix on as a criterion of form, he will be continually contradicting himself, and find at last that the great mother of nature will not be subjected to such narrow rules. Among the various reasons why we prefer one part of her works to another, the most general, I believe, is habit and custom: custom makes, in a certain sense, white black, and black white; it is custom alone determines our preference of the colour of the Europeans to the *Æthiopians*;

Nose.

Idler,
vol. ii.

Note.
Nofology.

pians; and they, for the same reason, prefer their own colour to ours. I suppose nobody will doubt, if one of their painters was to paint the goddess of beauty, but that he would represent her black, with thick lips, flat nose, and woolly hair: and it seems to me he would act very unnaturally if he did not; for by what criterion will any one dispute the propriety of his idea? We indeed say, that the form and colour of the European is preferable to that of the Ethiopian; but I know of no other reason we have for it, but that we are more accustomed to it. It is absurd to say, that beauty is possessed of attractive powers, which irresistibly seize the corresponding mind with love and admiration, since that argument is equally conclusive in favour of the white and the black philosopher.

"The black and white nations must, in respect of beauty, be considered as of different kinds, at least a different species of the same kind; from one of which to the other, as I observed, no inference can be drawn.

"Novelty is said to be one of the causes of beauty: that novelty is a very sufficient reason why we should admire, is not denied; but because it is uncommon, is it therefore beautiful? The beauty that is produced by colour, as when we prefer one bird to another, though of the same form, on account of its colour, has nothing to do with this argument, which reaches only to form. I have here considered the word beauty as being properly applied to form alone. There is a necessity of fixing this confined sense; for there can be no argument if the sense of the word is extended to every thing that is approved. A rose may as well be said to be beautiful, because it has a fine smell, as a bird because of its colour. When we apply the word *beauty*, we do not mean always by it a more beautiful form, but something valuable on account of its rarity, usefulness, colour, or any other property. A horse is said to be a beautiful animal; but had a horse as few good qualities as a tortoise, I do not imagine that he would be then esteemed beautiful.

"A fitness to the end proposed is said to be another cause of beauty; but supposing we were proper judges of what form is the most proper in an animal to constitute strength or swiftness, we always determine concerning its beauty before we exert our understanding to judge of its fitness.

"From what has been said, it may be inferred, that the works of nature, if we compare one species with another, are all equally beautiful; and that preference is given from custom, or some association of ideas; and that in creatures of the same species beauty is the medium or centre of all various forms." See the article BEAUTY, towards the end.

NOSOLOGY, is a Greek word signifying a discourse or treatise of diseases; otherwise called *pathology*.

The importance of a comprehensive and accurate nosology has been long and generally allowed. Baglivi, Boerhaave, Gorter, Gaubius, and Sydenham, have expressed their desire of a work of this kind, the great object of which is to fix pathognomonics to every disease; or in which all diseases are disposed into certain classes, orders, and genera, founded on distinctions taken from the symptoms only, without regard to remote or proximate causes.

Under the article MEDICINE, we have mentioned some of the most accurate nosological arrangements; and have here only to add, that, in 1776, Dr Sagar, at Iglaw in Moravia, published a *Systema Morborum Symptomaticum*, octavo, which is an useful abridgment of the work of M. Sauvages, with some alterations and additions. See MEDICINE, n° 123.

NOSTOCH, SHOT STARS; *tremella nostoc*, (Lia. Spec. Plant. Dillenius de Muscis, tab. 10. fig. 14. Flor. Danica, tab. 885. fig. 1.); *tremella intestinalis vel mesenterica*, (Lin. Spec. Plant. Dillen. de Musc. tab. 10. fig. 16. Flor. Danic. tab. 885. fig. 2.)

A writer in the Gentleman's Magazine gives this account of it: "The substance in question is not unfrequent in England, nor in all other parts of Europe, after rains, both in spring and autumn. Very large spots of it are seen in gravelly soils, and particularly on the tops of hills, and on open downs, and often it is found on gravel-walks.

"It is met with in some of the old authors, under the name of *nostoch*, as in Paracelsus and others; and the alchemists fancied there was something wonderful in it, and that it would afford a menstruum for gold. Nostoch is said to be a word synonymous to *faculum alicujus stelle, vel potius ejus repurgatione dejectum quid in terram; flos aeris; fragmentum nimbi*; as this substance was believed to fall from the sky with the meteors that we often see, and call *falling stars*. Hence the country people in Sweden have called it *sky-fall*; and in England it is known by the name of *witches butter*, in common with some of the gelatinous liverworts.

"Paracelsus, Helmont, and others, ranked it with the *terniabin*, or manna, and thought it dropped, as that did, from heaven. It is described, and the chemical analysis thereof given, by M. Geoffroy, in the Paris Memoirs for 1708, and is there said to yield, besides an acid phlegm, a portion of concrete volatile salt and some fixed salt. The distilled water from it was believed by some to possess singular virtues, in allaying pains of the joints; but there is certainly no room to attribute any extraordinary qualities to it.

"Since the days of Paracelsus it has been considered as a vegetable production; but the botanists have had difficulty to assign its place or genus in their several systems. Our own countryman, Dr Merret, seems to have been among the first authors who ranked it among vegetables, and he calls it *Lichen humiditate intumescens, siccitate evanescens* (Pin. page 71.) Others have retained it among the plants of that genus to this day; as does the celebrated Dr Haller, in his *Historia Stirp. Helvetiae*, who calls it *Lichen gelatinosus, plicatus, undulatus; laciniis crispatis, granulosis*, n° 2041 as there are several of the liverworts that have a gelatinous texture and appearance; though they differ much from the nostoch, in not being so instantly dried up. It was put into Ray's Synopsis, by Dr Dillenius, under the name of *Ulvæ terrestris pinguis et fugax*, p. 64. but he afterwards changed that name for *tremella*, in his *Historia Muscorum*, where he calls it *tremella terrestris sinuosa pinguis et fugax*, p. 52. tab. 10. f. 14. and reduces the lavers to the same genus. Micheli, an Italian botanist, famous for his attention to the Cryptogamia class of plants, makes it a *fungus*, as Magnol and Dr Morison had done before him, and describes and figures it, in his

Nostoch,

Nostoch. *Nova Plantarum Genera*, under the name of *Linkia terrestris gelatinosa, membranacea, vulgatissima*, p. 126. t. 67. f. 1. He describes the seeds as lying in the form of little strings of beads, coiled up within the plant, or rather in the folds thereof, and only to be discovered by the microscope. Linnæus mentions it, first under the name of *Byssus gelatinosa fugax terrestris*, in his *Flora Lapponica*, n° 530; but he afterwards adopted Dillenius's term, though he does not make it a laver. Linnæus has called it, in all his subsequent works, *tremella (nostoc) plicata, undulata*, under which name it stands in his *Species Plantarum*, p. 1157, and in Hudson's *Flora Anglica*, p. 463, as also in a numerous set of other authors who follow his system."

Another writer in the same work gives this account of it. "This substance is very rarely seen between the middle of April and the month of October. It is most frequently to be found on the high pasture lands, where the ground is inclined to wet, and on the moors and commons in the north of England. The time we always meet with it is after a very wet night, when the air in the morning suddenly clears up, and a sharp frost ensues. The frogs that then happen to be out are immediately seized by the frost, and turned into this jelly-like substance. For as I have had occasion sometimes to go out very early, I have found several parts of the frog not yet dissolved among the jelly, such as feet, legs, and thighs, yet in a little time afterwards the change was fully completed. The quantity of jelly produced from one single frog is almost beyond belief, even to five or six times its bulk when in its natural state.

"I communicated this discovery to an acquaintance, who has since had frequent opportunities of observing and examining this production; and we are fully assured, that, whatever opinion the learned may have of it, it certainly proceeds from the above-mentioned cause wherever found.

"Most people that I have conversed with on the subject, are of opinion that this jelly falls from the stars, or out of the higher regions of the air; which notion, however absurd, many are credulous enough to believe."

Naturalists had for some years begun to doubt whether these gelatinous substances were of a vegetable or animal nature, when at length Mr J. Platt of Oxford, in his letter printed in the Gentleman's Magazine for 1776, page 402, threw such light on the subject as to us, at least, is perfectly satisfactory.

"From a child I remember seeing the meteors shooting in the air, which appearance, by my comrades, was called *star-shooting*, believing the stars no larger than their apparent magnitude. This jelly-like substance, mentioned in your magazine, was believed to be the drops of these meteors, and took the name of *star-shot*, which passed for certain with me till I had arrived at the age of 24, when I was engaged in business that required my frequently passing over both meadows and pasture-grounds, where in spring and autumn I saw many portions of this supposed alga or nostoch, but never more than one or two contiguous, mostly near the water, when the meadows were or had been just before flooded. My conjectures were various until I saw a crow pecking of something in a field, which I heard to cry; when turning my horse to the place, I found a frog of the common size, which the

crow (of the carrion kind) would soon have killed and gorged, had I not disturbed her, and chased her away.

"About this time I found in a meadow the bowels of a frog indigested, and compact as the chitterlings of a calf or pig; but white as the paper I write upon, though not translucent. I took it up, and placed it in a paper exposed to the air; leaving it in some grass where I found it, till my return that way in three days time, when I saw it changed to that tremulous jelly-like substance, the alga or star-shot. I was much pleased with this discovery, and took it home in my pocket wrapped in paper, where I showed it to a society of young persons of which I was a member, who agreed with my sentiments of its being the indigestible part of a frog disgorged by some bird of prey.

"To corroborate my sentiments of this alga being the bowels of a frog, I luckily saw some of it lying by the side of a brook, where I lighted and took it up, and to my great surprise found attached to the jelly the head, heart, liver, and one leg of the frog, which had been (I presume) disgorged by some carrion crow, who frequented the flooded grounds to pick up worms and other vermin. There was also some of it found in an apple-tree at Wynton Magna, near Leicester, where I then lived, which, no doubt, was disgorged by some owl."

Dr Darwin, in his Poem on the Loves of the Plants, is of the same opinion with Mr Platt, that these gelatinous substances are of an animal nature, and that the different appearances they put on are owing to various circumstances, viz. the different birds who feed on frogs, the quantity they devour at a time, and the state of digestion before they are voided.

NOSTRADAMUS (Michel), an able physician and a celebrated astrologer, was a Provencal, and descended of a noble family, and born Dec. 14. 1503, at St Remy, in the diocese of Avignon. By his grandfather he was initiated in the study of the mathematics. He afterwards completed his courses of humanity and philosophy at Avignon; and, going thence to Montpellier, he there applied himself to physic, till being forced away by the plague in 1525, he took his route towards Thoulouse, and passed on till he came to Bourdeaux. This course held him five years; during which he undertook the cure of all such patients as were willing to put themselves under his care. After this he returned to Montpellier, and was created doctor of his faculty in 1529, and then revisited the same places where he had practised physic before. At Agen he contracted an acquaintance with Julius Cæsar Scaliger, which induced him to make some stay in that town, and there he entered into matrimony; but having buried his wife, and two children which she brought him, he quitted Agen after a residence of about four years. He returned into Provence, and fixed himself first at Marseilles; but his friends having provided an advantageous match for him at Salon, he transported himself thither in 1544. In 1546, Aix being afflicted with the plague, he went thither at the solicitation of the inhabitants, and was of great service; particularly by a powder of his own invention: so that the town in gratitude gave him a considerable pension for several years after the contagion ceased. Returning afterwards to Salon, he became a recluse, and made use of

Nostradamus.

his leisure to apply himself to his studies. He had a long time followed the trade of a conjurer occasionally; and now he began to think himself inspired, and miraculously illuminated with a prospect into futurity. As fast as these illuminations had discovered to him any future event, he entered it in writing, in simple prose, but by enigmatical sentences, as he declared himself; but revising them afterwards, he thought the sentences would appear more respectable, and would favour more of a prophetic spirit if they were expressed in verse. This opinion determined him to throw them all into quatrains, and he afterward ranged them into centuries. When this was done, he hesitated about making them public, till reflecting that the time of many events which he had foretold was very near at hand, he determined to print them. This he did with a dedication addressed to his son Cæsar, an infant only some months old, in the form of a letter or preface, dated March 1. 1555. This first edition, which is included in seven centuries, was printed by Rigault at Lyons. He prefixed his name in Latin, but gave to his son Cæsar the name as it is pronounced, *Nostradamus*.

The public were divided in their sentiments of this work: many looked upon the author as a simple visionary or a fool; while he was accused of the black art, or black magic, by others, and treated as an impious person, who held a commerce with the devil: at the same time there were not wanting such, and those in great numbers, who believed him to be really and truly endued with the supernatural gift of prophecy. Lastly, some were found who remained in suspense, and refrained from giving any judgment at all upon the point. However, Henry II. and queen Catharine of Medicis his mother, were resolved to see our prophet; and, receiving orders to that effect, he presently repaired to Paris. He was very graciously received at court; and, besides the extraordinary respect that was paid to him, received a present of 200 crowns. He was sent afterwards to Blois, to make a visit to his majesty's children there, and report what he should be able to discover concerning their destinies. No doubt he exerted himself to the utmost on the occasion; but what his sentence was is not known: however, it is certain, he returned to Salon loaded with honour and presents. Animated with this success, he augmented his work from 300 quatrains to the number of a complete milliade, and published it with a dedication to the king in 1558. That prince dying the next year of a wound which he received, as is well known, at a tournament, the book of our prophet was immediately consulted; and in the 35th quatrain of the first century this unfortunate event was found predicted in the following verse:

*Le lion jeune le vieux surmontera,
En champ bellique par singulier duel,
Dans cage d'or les yeux lui crevera,
Deux classes une puis mourir, mort cruelle.*

So remarkable a prediction added new wings to his fame; and he was honoured shortly after with a visit from Emanuel duke of Savoy and the princess Margaret of France his consort. From this time Nostradamus found himself even over-burdened with visitors, and his fame made every day new acquisitions. Ch. IX

coming to Salon, was eager above all things to have a sight of him. Nostradamus, who then was in waiting as one of the retinue of the magistrates, being instantly presented to his majesty, complained of the little esteem his countrymen had for him; whereupon the monarch publicly declared, that he should hold the enemies of Nostradamus to be his enemies, and desired to see his children. Nor did that prince's favour stop here; in passing, not long after, through the city of Arles, he sent for Nostradamus, presented him with a purse of 200 crowns, together with a brevet, constituting him his physician in ordinary, with the same appointment as the rest. But our prophet enjoyed these honours only for the space of sixteen months, for he died July 2. 1566, at Salon. Besides his "Centuries," we have the following compositions of his: *A Treatise de fardemens & de senteurs*, 1552.—*A Book of singular Receipts, pour entretenir la santé du corps*, 1556.—*A Piece des confitures*, 1557.—*A French Translation of the Latin of Galen's Paraphrase, exhorting Menedolus to study, especially to that of physic*, 1552. Some years before his death, he published a small instruction for husbandmen, showing the best seasons for their several labours, which he intitled, *The Almanac of Nostradamus*. Lastly, after his death there came out *The eleventh and twelfth Centuries of his Quatrains*, added to the former ten, which had been printed three times in two separate parts. It is only in these first editions that our author's Centuries are found without alterations, additions, &c. It is to this work that the following distich of Stephen Jodelle alludes.

*Nostra damus, cum falsa damus, nam fallere nostrum est.
Et cum falsa damus, nil nisi Nostra damus.*

NOSTRE (Andrew le), comptroller of the buildings of the French king, and designer of his gardens, distinguished himself by carrying the art of laying out gardens to great perfection. He was born at Paris in 1631; and was near 40 years of age when M. Fouquet, superintendant of the finances, gave him an opportunity of becoming known by the fine gardens of Vaux-le-Vicomte. He was afterwards employed by Louis XIV. at Versailles, Triannon, St. Germain, &c. and discovered an admirable taste in all his works. In 1678 he went to Rome, with the permission of the French king, to improve his skill; but he found nothing there comparable to what he himself had done. Pope Innocent XI. resolved to see Le Nostre, and gave him a pretty long audience; at the conclusion of which Le Nostre said, "I have seen the two greatest men in the world, your holiness, and the king my master." There is a great difference, answered the pope: "The king is a great victorious prince; and I am a poor priest, the servant of the servants of God." Le Nostre, charmed with this answer, and forgetting who he was with, clapped the pope on the shoulder, saying, "Reverend father, you look extremely well, and will live to bury all the sacred college." The pope laughed at his prediction. Le Nostre, charmed more and more at the goodness of the sovereign pontiff, and the singular esteem he showed for the king, threw his arms about the pope's neck and kissed him. It was his custom to behave in the same manner to all who spoke in praise of Louis XIV. and he

Nostradamus, Nostre.

Notæ.

he even embraced the king himself whenever that prince returned from the country. Le Nostre had also a talent for painting. He preserved his good sense and vivacity of mind to the end of his life; and died at Paris in 1700, aged 87.

† *Asle's*
Origin and
Progress of
Writing.

NOTÆ, signs used in writing, which have the force of many letters. This contrivance for expedition is of great antiquity. It was known to the Greeks, and from them derived to the Romans. By whom the invention was brought into Rome is not precisely ascertained; but the most general opinion † is, that in matters of importance Tully first made use of notes or short-hand writing, when Cato made an oration in order to oppose Julius Cæsar relative to the conspiracy of Catiline. Cicero, who was at that time consul, placed *notarii*, or expert short-hand writers, in different parts of the senate-house, to take down the speech; and this was the first public occasion which we find recorded of employing short-hand writers among the Romans. It is unnecessary to observe, that hence proceeded the name of *notary* still in use.

There were three kinds of notes for short-hand writing used by the ancients, either for dispatch or secrecy. The first and most ancient was that of hieroglyphics, which are rather images or representations of things than of words. (See *HIEROGLYPHICS*.) The Chinese characters are of this kind, and may with greater propriety be called *notæ* than *litteræ*, as appears from what hath been already advanced.

The second species of notes were called *singulariæ*, from their expressing words by single letters. Sertorius Ursatus has compiled a very copious collection of such abbreviations, of which work there are several editions.

The third kind of notes were called *notæ Tironianæ*, from Tiro the freed man of Cicero, who was excellently skilled in this art; and it is to him that we are indebted for the preservation of Cicero's letters, of which a great part still remain; and one entire book of them written to Tiro himself.

From books it appears, that notes were very frequent among the Romans, and continued in use to the 10th and 11th centuries. We have indeed but few books remaining that are written in short-hand; but this is not surprising, when such was the unhappy situation of early ages, that either superstition condemned them to the flames as the works of impious magicians or necromancers, or they were left to be devoured by vermin, through ignorance and stupidity, which was so very great, that some people, as Trithemius affirms, looked upon notes in those days as the elements of the Armenian language. It is probable, however, that there are writings of this sort still extant, which might contribute to enrich the republic of letters.

There are several MSS. and instruments written in these kind of notæ, in the royal library at Paris. In the year 1747, the learned and ingenious Mons. Carpentier, engraved and published at Paris a capitulary, and 4 charters of Louis the Pious, emperor and king of France, written in these notæ Tironianæ. To this work the learned editor hath prefixed an *Alphabetum Tironianum*, together with a great number and variety of notes or marks for the different parts of speech, and rules for acquiring the art of writing in these kind of notes. Valerius Probus, in his book *De Literis*

antiquis, explains many of the characters used by the short-hand writers; and there is a dictionary of them set forth by Janus Gruterus. See *STENOGRAPHY*.

NOTARI, persons employed by the Romans to take, by *notæ*, trials and pleadings in their courts of judicature, or to write as amanuenses from the mouth of an author. These notarii were of servile condition. Under the reign of Justinian, they were formed into a college or corporate body. Notarii were also appointed to attend the prefects, to transcribe for them. There were likewise *notarii domestici*, who were employed in keeping the accounts of the Roman nobility; and when the empire became Christian, there were notaries for ecclesiastical affairs, who attested the acts of archbishops, bishops, and other spiritual dignitaries. We find ecclesiastical notaries at Rome, under Pope Julius IV. and in the church of Antioch, about the year 370. From these notaries are derived the office of chancellor to the bishops; afterwards almost every advocate was admitted a notary.

NOTARY (NOTARIUS), signifies a person, usually some scrivener, who takes notes, or frames short draughts, of contracts, obligations, charter-parties, or other writings. At present we call him a *notary-public*, who publicly attests deeds or writings, in order to make them authentic in another nation; but he is principally employed in business concerning merchants; as making protests of bills of exchange, &c. And noting a bill, is where he goes to take notice of a merchant's refusal to accept or pay the same.

NOTATION, in arithmetic and algebra, the method of expressing numbers or quantities by signs or characters appropriated for that purpose. See *ARITHMETIC* and *ALGEBRA*.

NOTES, in music, characters which mark the sounds, *i. e.* the elevations and fallings of the voice, and the swiftness and slowness of its motions.

NOTE is likewise used for a mark made in a book or writing, where there occurs something remarkable and worthy of particular notice: as also for an observation or explication of some passage in an author added in the margin, at the bottom of the page, or elsewhere; in which sense it stands contradistinguished to *text*.

NOTE, is also a minute, or short writing, containing some article of business; in which sense we say, promissory note, note of hand, bank-note, &c.

NOTHUS, signifies *spurious*, or *bastard*; whence it is figuratively applied by physicians to such diseases as, though in respect of a similitude of symptoms, &c. they have the same denomination as some others, yet are of a different origin, seat, or the like, from the same.

NOTHUS, a Persian prince, and grandfather to Darius Codomannus. He is worthy of being mentioned only as he was progenitor to that sovereign whose overthrow conferred upon Alexander the title of *Great*.

NOTION, a word which in common language is considered as of the same import with *idea*. This, however, is improper. Notion comprehends the meaning of *idea*, but it denotes much more. We have a notion of spirit, of power, of solidity; but of these things we can have no ideas. Ideas are relicts of sensation; but there are objects of knowledge which fall under the cognizance of no sense; of these objects, however, we may have very distinct notions either direct or relative. See *METAPHYSICS*, n° 11.

NOTITIA,

Notarii
||
Notion.

Notitia ||
Notonecta. **NOTITIA**, in literary history, a book that gives an account of a particular country, city, or other place: such is the *Notitia Imperii Romani*, *Notitia Romæ Antiquæ*, &c.

NOTO, an ancient, large, and handsome town of Sicily, and capital of the Val-di-Noto. It was entirely ruined by an earthquake in 1693; but the inhabitants built another town at some distance from it, which they call *Noto Nuovo*. E. Long. 14. c. N. Lat. 36. 50.

NOTO (Val-di), one of the three valleys or provinces into which Sicily is divided; and it lies between the sea, Val di Demona, and Val di-Mazara. Noto is the capital town.

Plate
cccxlvi.

NOTONECTA, the boat-fly; a genus of insects belonging to the order of hemiptera. Barbut gives the following character of this genus. "The rostrum is inflected; the antennæ are shorter than the thorax; the four wings, which are coriaceous from their base to their middle, are folded together cross-wise; the hind feet are hairy, and formed for swimming. To which may be added, that the tarsi are composed of two articulations, and all the six feet are equally formed for swimming. The abdomen terminated by four little horns or appendices." He also describes the notonecta glauca, Linn. n. 1. in these words. "This insect has a head somewhat round, of which the eyes seem to take up the greatest part. Those eyes are brown and very large, the rest of the head being yellow. In the fore part it has a sharp trunk that projects, and is inflected between the fore feet. On the sides are seen the antennæ, very small, yellowish, and that spring from under the head. The thorax, which is broad, short, and smooth, is yellow on the fore and black on the back part. The escutcheon is large, of a rough black, and as it were nappy. The elytra, rather large, and crossed over each other, are a mixture of brown and yellow, not unlike the colour of rust, which makes it look cloudy. The under part of the body is brown; and at the extremity of the abdomen are to be seen a few hairs. The feet, six in number, are of a light brown, the two hindmost having on the leg and tarsus hairs that give them the shape of fins, nor are they terminated by nails. The four anterior ones are somewhat flat, and serve the animal to swim with; but at their extremity they have nails and no hairs. This insect is seen in stagnating waters, where it swims on its back, and presents its abdomen upwards; for which reason it has been called by the Greek name of *notonecta*. The hinder feet, longer than the rest, serve it as paddles. It is very nimble, and dives down when you go to take hold of it; after which, it rises again to the surface of the water. It must be cautiously handled if one would avoid being pricked by it, for the point of its rostrum is exceeding sharp and intolerably painful, but it goes off in a few minutes. The larva very much resembles the perfect insect." Such is the account that Mr Barbut gives of this beautiful nimble little creature, which we thought it our duty to lay before our readers, as this gentleman seems to have been particularly attentive to the subject. To this account, however, we shall add the following. Its legs are long; when taken out of the water it hops: it is very common in the ponds of water in Hyde-park, and in several other places about London. It is of a very

particular form, being flattish at the belly, and rising to a ridge on the middle of the back; so that when it swims, which is almost always on the back, its body has much the resemblance of a boat in figure, and whence its vulgar name. It is eight lines long, three broad, and two and a half thick. The belly is jointed, striated, and, as Barbut observes, hairy. Nature has provided it with an offensive weapon resembling a sting, which it thrusts out when hurt from a large opening at the tail. The head is large and hard. The eyes of nearly a triangular form. The nose is a long, green, hollow proboscis, ending in a hard and sharp point, which in its natural posture remains under the belly, and reaches to the middle pair of legs. The outer pair of its wings are of a pale flesh-colour, with spots of a dead white; these are long, narrow, and somewhat transparent: they terminate in a roundish point, and perfectly cover the whole body. The triangular piece which stands between the top of the wings is hard, and perfectly black; the inner wings are broader and shorter than the outer ones; they are thin and perfectly transparent, and are of a pale pearl colour. The hinder pair being greatly longer than all the rest, they serve as oars; and nature has tufted them with hair at the end for that purpose. This creature mostly lives in the water, where it preys on small insects, killing them and sucking their juices with its proboscis, in the manner of the water scorpion and many other aquatic insects; and it seizes its prey violently, and darts with incredible swiftness to a considerable distance after it.

Though it generally lives in the water, it sometimes, however, crawls out in good weather; and drying its wings by expanding them in the sun, takes flight, and becomes an inhabitant of the air, not to be known for the same creature, unless to those who had accurately observed it before; when tired of flying, or in danger of an enemy, it immediately plunges into the water. We are told that there are 14 species of it, seven of which are common in Europe in waters, &c.

NOTTEBURG, a town of Russia, in the province of Ingria, seated on an island in the lake Ladoga, at the place where the river Nieva proceeds from this lake. It is strong, has a good citadel, and was capital of the province before Petersburg was built. E. Long. 31. 40. N. Lat. 60. 0.

NOTTINGHAMSHIRE, a county of England, bounded on the east by Lincolnshire, on the south-east and south by Leicestershire, on the west by Derbyshire, and on the north and north-west by Yorkshire. It extends in length 48 miles, 25 in breadth, and 110 in compass; containing 560,000 acres, 8 hundreds, 9 market-towns, 168 parishes, 450 villages, about 17460 houses, and 95000 inhabitants. No county in England enjoys a pleasanter and healthier air. As for the soil, it differs widely in different parts of the county. Towards the west, where lies the forest of Sherwood, it is sandy; and therefore that part of the county is called by the inhabitants the *Sand*: but the south and east parts, watered by the Trent and the rivulets that fall into it, are clayey; and for that reason are called by the inhabitants the *Clay*. The latter is fruitful both in corn and pasture; but the former produces little besides wood, coal, and some lead. The county has a variety of commodities and manufactures, as wool, leather, tallow,

Notonecta ||
Nottinghamshire.

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low, butter, cheese, coal, marl, cattle, malt, liquors, rice, stockings, glass, earthen-ware, and strong ale. The principal rivers are the Trent and Idle. The Trent, whose name is supposed to be derived from the French or Latin word signifying *thirty*, either because it receives thirty smaller rivers, or has thirty different sorts of fish in it, is inferior to no river in England, but the Severn, Thames, and Humber. It enters the county on the south-west, and passes through it to the north-east, where it enters Lincolnshire, and after a long course falls at last into the Humber. The Idle rises in Sherwood-forest; and after traversing the northern part of the county, falls into the Trent upon the borders of Yorkshire and Lincolnshire.

The spacious forest of Sherwood lies in the west part of the county, and indeed takes up the greatest part of it. It was formerly so thick, that it was hardly passable; but now it is much thinner. It feeds an infinite number of deer and stags; and has some towns in it, of which Mansfield is the chief. It abounds in coal, and a road lies through it for thirty miles together. Since the reign of King Edward I. the nobility and gentry have had grants of it. It was governed by a great number of officers under the late earl of Chesterfield, chief forester; whose ancestor, Sir John Stanhope, had a grant of it, with liberty to destroy and kill at pleasure, reserving only an hundred deer in the whole walk. The duke of Newcastle is now steward and keeper. The principal town is

NOTTINGHAM, which gives name to the county. It is a handsome town, and a county of itself by charter. The name is derived from the Saxon word *Snottengham*, which signifies *caves*, from the caves and apartments anciently dug in the rocks on which the town stands. These, being soft, easily yield to the spade and pickaxe; whence the townsmen have excellent cellars for the vast quantities of malt liquors made here, and sent, as well as their malt, to most parts of England. The situation of the town is very pleasant, having meadows on one hand, and hills of a gentle, easy ascent, on the other. It is well supplied with fuel, both wood and coal, from the forest; and with fish by the Trent, which runs about a mile to the south of it, and has been made navigable for barges: so that they receive by it not only great quantities of cheese from Warwickshire and Staffordshire; but all their heavy goods from the Humber, and even from Hull. Over the Trent is a stately stone-bridge of 19 arches, where the river is very large and deep, having received the addition of the Dove, the Derwent, the Irwash, and the Soar, three of them great rivers of themselves, which fall into it after its passing by Burton in Staffordshire.

The town is of great antiquity, and it had formerly a strong castle, in which the Danes, in the time of the heptarchy, held out a siege against Buthred king of Mercia, Alfred, and Ethelred his brother, king of the West Saxons.

Soon after the conquest, William either repaired this fortress or built a new one on the same spot, in the second year of his reign, probably to secure a retreat on his expedition against Edwin Earl of Chester and Morcar Earl of Northumberland, who had revolted. He committed the custody of it to William Peverell, his natural son, who has by some been confi-

dered as the founder. It stands on a steep rock, at the foot of which runs the river Leen.

Deering, in his history of Nottingham, seems very justly to explode the story of the place called Mortimer's-hole, having been made as a hiding-place for him; and from his description of it, shows that it was meant as a private passage to the castle, to relieve it with men or provisions in a siege. He says that it is one continued stair-case, without any room, or even a place to sit down on. It was by this passage that Edward III. got into the castle and surprized Mortimer and the queen; and from hence, and his being carried away through it, it has its name.

Edward IV. greatly enlarged the castle, but did not live to complete the buildings he begun. Richard III. finished them.

It was granted by James I. to Francis Earl of Rutland, who pulled down many of the buildings; but it was still of so much strength, that Charles I. in 1642, pitched on it as the place for beginning his operations of war. He set up his standard, first on the walls of the castle, but in two or three days removed it to a close on the north-side of the castle, without the wall, on a round spot; after which it was for many years called Standard-close, and since, from the name of one who rented it, Nevil's close. Where the standard was fixed, there stood a post for a considerable time. It is a common error that it was erected on a place called Derry-mount, a little further north than the close just mentioned; this is an artificial hill raised on purpose for a wind-mill, which formerly was there. The castle was afterwards sequestered by the parliament, and the trees in the park cut down.

This castle was so strong that it was never taken by storm. After the civil war, Cromwell ordered it to be demolished. On the restoration, the duke of Buckingham, whose mother was daughter and heir of this Francis Earl of Rutland, had it restored to him, and sold it to William Cavendish, marquis and afterwards duke of Newcastle. In 1674 he began the present building, but died in 1676, when the work was not far advanced. However, he had the building of it so much at heart, that he left the revenue of a considerable estate to be applied to that purpose, and it was finished by Henry his son. The expence was about 14,000l. It is one of the seats of the present duke of Newcastle.

In the park, west of the castle, and facing the river Leen, are some remains of an ancient building (if it may be so called) cut and framed in the rock. Dr Stukeley gives it, as he does most things, to the Britons. Many other ancient excavations have been found in other parts of the rocks.

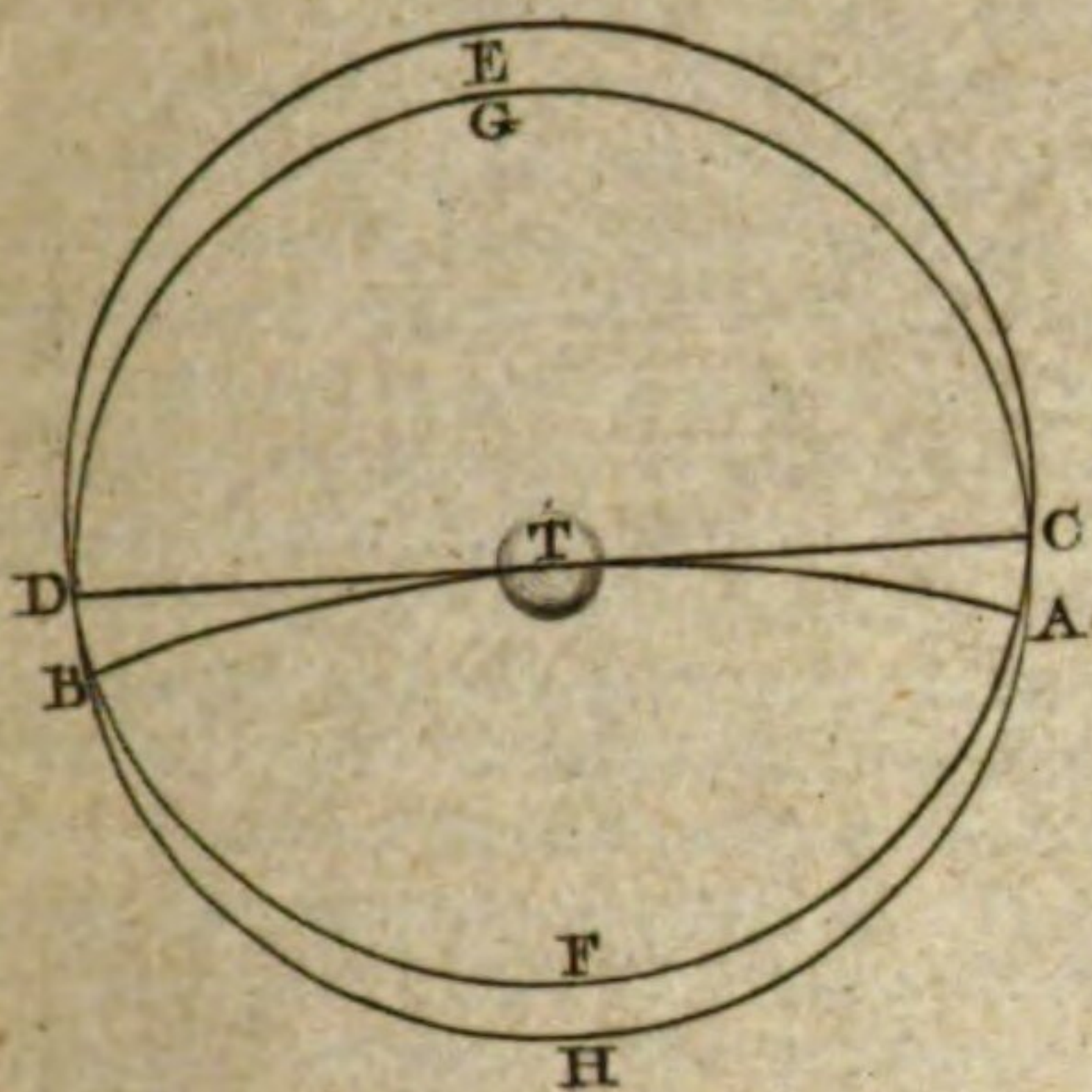
The frames for knitting stockings were invented by one William Lea of this county, about the beginning of the last century; but he not meeting with the encouragement he expected (a case too common with the first inventors of the most useful arts), went with several of his workmen to France, on the invitation of Henry IV. The death of that king, and the troubles which ensued, prevented attention being given to the work. Lea died there, and most of his men returned to England. Other attempts were made to steal the trade, without better success, and it has flourished here ever since, and is now carried on to a very considerable extent.

Notting-
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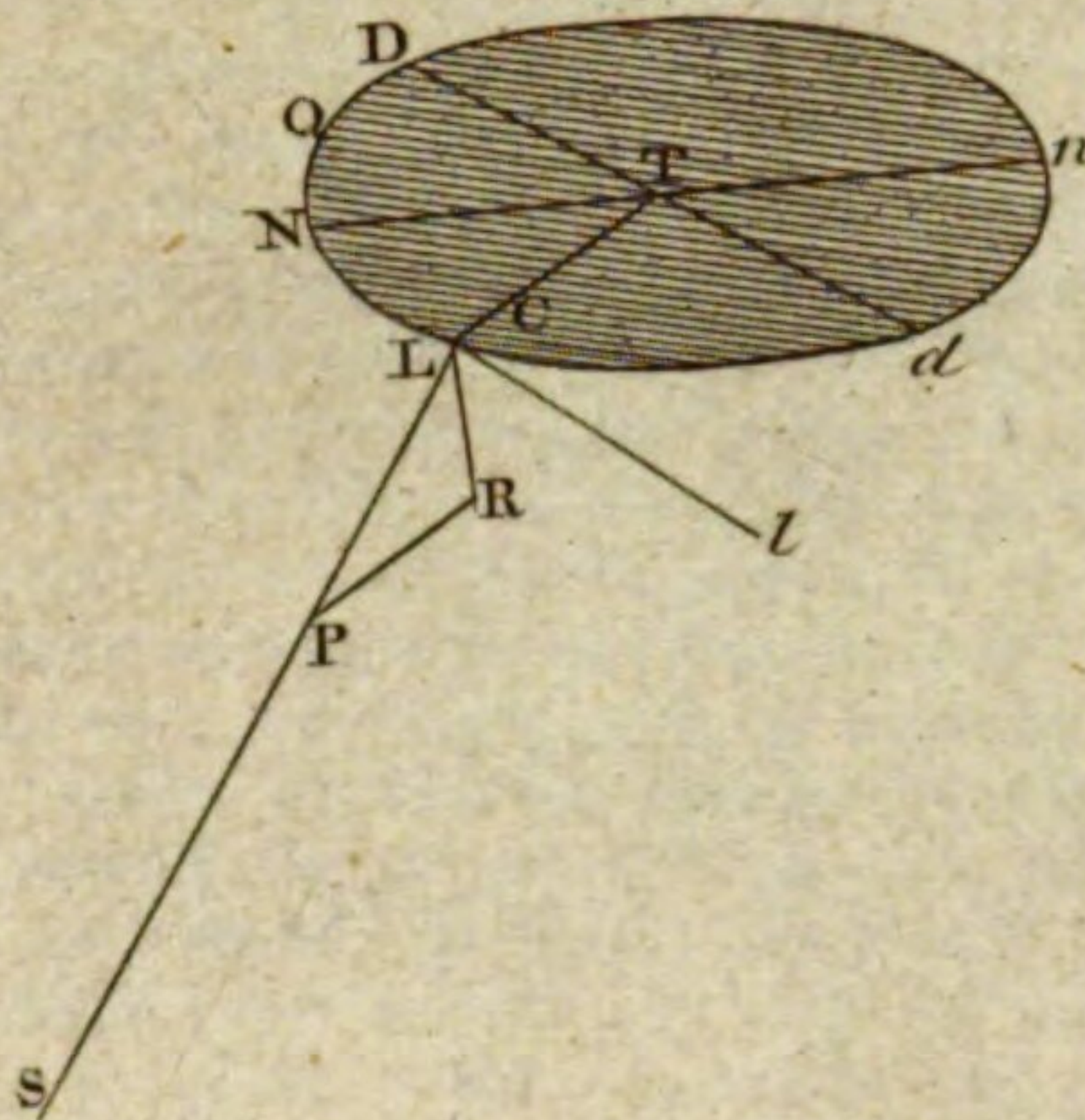
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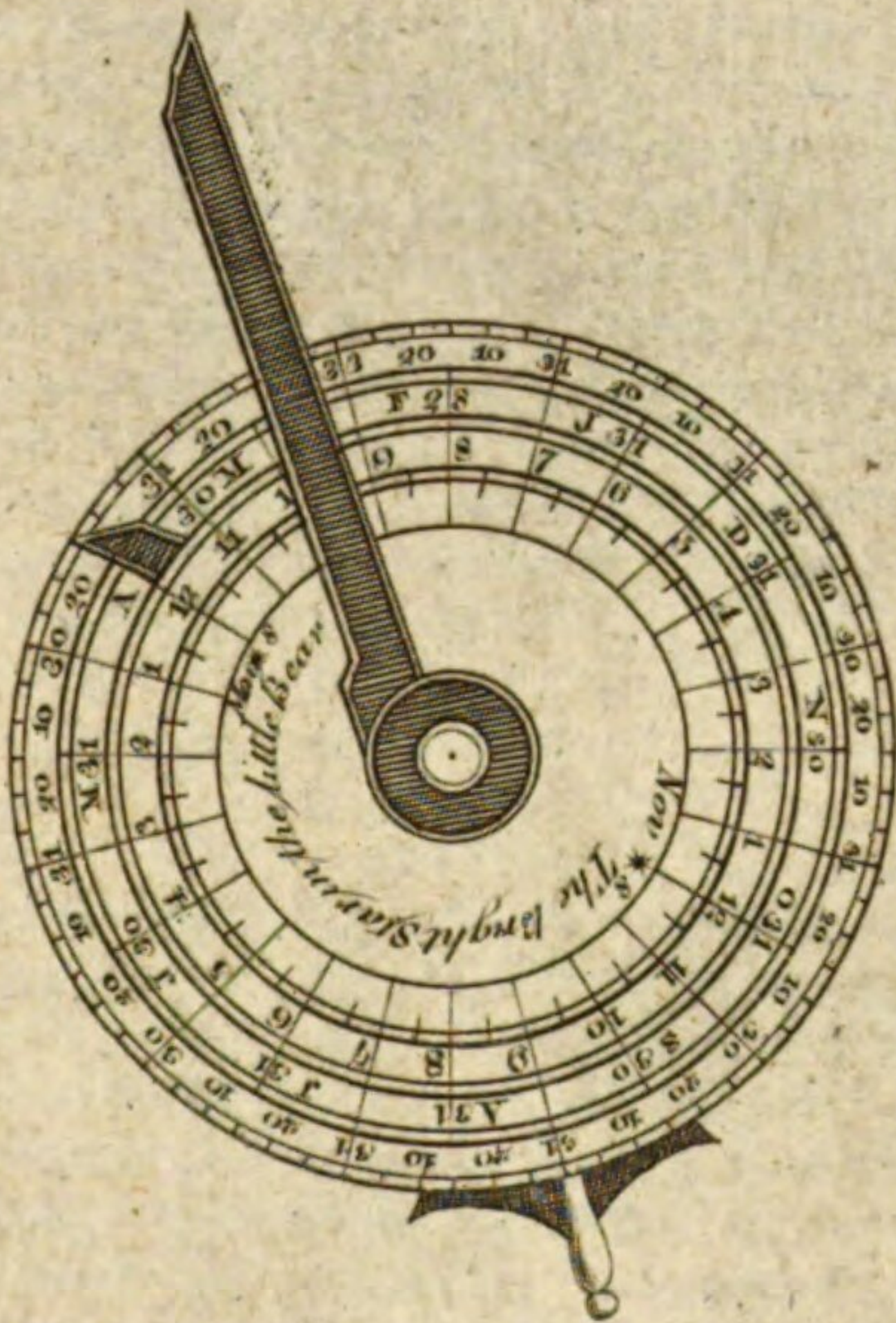
N.º 1.



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Nocturnal.



Nopalxochquetzalli.



Notonecta



A. Bellin Hal. sculpt. fecit

Notting-
ham
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Novatian.

extent. It is noted for its horse-races on a fine course on the north side of the town. The corporation is governed by a mayor, recorder, six aldermen, two coroners, two sheriffs, two chamberlains, and twenty-four common-council men, eighteen of the senior-council, and six of the junior, a bell-bearer, and two pinders, one for the fields and the other for the meadows. The town being within the jurisdiction of the forest, the former of these pinders is town-woodward, and attends the forest courts. It has three neat churches, the chief of which is St Mary's; and an alms-house, endowed with 100l. a-year, for twelve poor people; with a noble town house, surrounded with piazzas. A considerable trade is carried on in glass and earthen wares, and frame-stockings, besides the malt, and malt-liquors, mentioned above. Marshal Tallard, when a prisoner in England, was confined to this town and county. In the duke of Newcastle's park there is a ledge of rocks hewn into a church, houses, chambers, dove-houses, &c. The altar of the church is natural rock; and between that and the castle there is an hermitage of the like workmanship. Upon the side of a hill there is a very extraordinary sort of a house, where you enter at the garret, and ascend to the cellar, which is at the top of the house. Here is a noted hospital founded by John Plumtree, Esq; in the reign of Richard II. for thirteen poor old widows. There are four handsome bridges over the Trent and Lind. To keep these in repair, and for other public purposes, the corporation has good estates. This town and Winchelsea both give title of earl to the noble family of Finch. Here David king of Scots, when a prisoner in England, resided; and under-ground is a vault, called *Mortimer's hole*, because Roger Mortimer earl of March is said to have absconded in it, when he was taken and hanged by order of Edward III. W. Long. 1. 5. N. Lat. 53.0.

NOVA-SCOTIA. See *Nova-SCOTIA*.

NOVA Zembla. See *Nova ZEMBLA*.

NOVALLE, a small, rich, and populous town of Italy, between Padus and Treviso. E. Long. 12. 5. N. Lat. 45. 35.

NOVARA, an ancient and strong city of Italy, in the duchy of Milan, and capital of the Novarese. Some pretend that this city was built by the Trojans, and so called *quasi Nova Ara*, because they had erected there a temple to Venus. Tacitus mentions its being made a municipal city by the Romans; and there are many inscriptions still extant, which sufficiently prove its ancient splendor. It is now a small but well-built town, situated on a little eminence, in a fine country, betwixt two rivers very well fortified, and is the see of a bishop suffragan of Milan. It is remarkable for the several sieges sustained in past times, and for being the birth-place of Peter Lombard, master of the sentences. E. Long. 8. 35. N. Lat. 45. 25.

NOVATIAN, who made so much noise and so greatly disturbed the peace of the church, was, we are told, first a Pagan philosopher. He was baptized in bed when dangerously ill: recovering, however, he was afterwards ordained priest of the church of Rome, his bishop having obtained this favour for him, which the clergy and people were far from being disposed to

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grant. He does not appear to have had the good of the church much at heart; for with his wit, knowledge, and eloquence, he might have been peculiarly serviceable to her, had he not with cowardice shrunk from his duty when he dreaded persecution. His ambition to be made a bishop likewise misled him; and what occasioned the apostacy of most of the first heresiarchs, also occasioned his. On the death of Fabian bishop of Rome, after writing a letter to St Cyprian, he remained quiet whilst the see was vacant; but the promotion of Cornelius to that dignity excited his envy and jealousy to no common pitch. The consequence was a separation from the new bishop, and from those who professed to believe, what Novatian strenuously denied, that the church could receive those again who had been guilty of idolatry. He soon got a number of followers among the laity, and some even among the clergy. Novatus, a priest of Carthage, was one of his party, and having been a party-man himself against St Cyprian, brought his adherents with him. He got himself consecrated Bishop of Rome in a most infamous and clandestine manner, by three weak men whom he had most grossly imposed upon, and one of whom did penance for having been concerned in what was so contrary to order, decency, and the rules of the church.

His designs, however, in this disgraceful affair did not succeed, for he was not acknowledged as bishop of that diocese; Cornelius being confirmed in it, whilst he was condemned and excommunicated. He still, however, taught his doctrine, and at length became the head of the party which bears his name. Besides the letter mentioned above, St Jerome says he wrote on the *Passover*, on the *Sabbath*, on *Circumcision*, on the *High Priests*, on *Prayer*, on *Jewish meals*, and on *Firmness of mind*, &c. with a large treatise on the *Trinity*. None of them appear under his own name, and some are thought not to be his.

NOVATIANS, *Novatiani*, a sect of ancient heretics, that arose towards the close of the third century, so called from Novatian, a priest of Rome, (see the preceeding article). They were called also *Cathari*, from *καθαροί*, *pure*, q. d. Puritans.

Novatian first separated from the communion of pope Cornelius, on pretence of his being too easy in admitting to repentance those who had fallen off in times of persecution.

Novatus coming to Rome, joined himself to the faction of Novatian; and both maintained, that there was no other admission into the church but by the repentance in baptism; grounding their opinion on that of St Paul: "It is impossible for those once enlightened, and who have tasted the heavenly gift, "if they fall away, to renew themselves by repentance."

Not that they denied but a person fallen into any sin, how grievous soever, might obtain pardon by repentance; for they themselves recommend repentance in the strongest terms: but their doctrine was, that the church had it not in its power to receive sinners into its communion, as having no way of remitting sins but by baptism; which once received could not be repeated.

In process of time the *Novatians* softened and moderated

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Novatian,
Novatians.

Novation
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Novel.

derated the rigour of their master's doctrine, and only refused absolution to very great sinners.

The two leaders were proscribed, and declared heretics, not for excluding penitents from communion, but for denying that the church had a power of remitting sins. See NOVATUS.

NOVATION, or INNOVATION, in the civil law, denotes the change of one kind of obligation for another; as when a promise is accepted instead of a written obligation.

NOVATUS, a priest of Carthage, in the third century, who, to avoid being punished for a crime, joined with the deacon, named *Felicissimus*, against St Cyprian. He went to Rome in 251; and there found Novatian, who had acquired great reputation by his eloquence, but who murmured at his not being raised to the see of Rome in preference to Cornelius. Novatus contracted a friendship with him; and afterwards promoted the detestable consecration of Novatian to the see of Rome. This irregular consecration produced a very great schism: Novatus also maintained, that the church had not the power to receive those to communion who were fallen into idolatry.

NOVEL, a fictitious narrative in prose, which professes to exhibit the natural workings of the human heart, the happiness and misery of private life, and, above all, the nature of the affection called *Love*, and the consequence of indulging it in certain circumstances.

The novel sprung out of the old romance, and has been censured for insipidity, as its parent was for extravagance. (See ROMANCE.) That the greater part of those absurd things, which, under this title, are daily issuing from the press, deserve all the contempt with which they can be treated, is a position which we feel not ourselves inclined to controvert; but we cannot admit that any species of writing is in itself insipid, merely because numbers have attempted it without success. The heroic poems of Blackmore are universally known to be contemptible performances; and if we had before us all the heroic poetry that has ever been written, how many thousands of volumes should we have as mean as either *Prince Arthur*, *King Arthur*, *Elize*, or *Alfred*? Yet no critic has hitherto dared to maintain, that heroic poetry is an insipid species of writing.

But to the novel objections have been urged of more importance than its insipidity. It has been often affirmed with learned solemnity, that the perusal of novels tends to corrupt the youth of both sexes; to produce effeminacy in men and extravagant notions of the happiness of love in women; that it diverts the minds of the former from more serious and useful studies, and exposes the latter to the arts of seduction. That there are too many novels to which this objection is applicable in its full force, is a fact which we are afraid cannot be denied: but when it is admitted, let not these performances be again accused of insipidity; for were they insipid, they could have no such consequences. It is by laying fast hold of the heart that they lead it astray. That a novel might be written so as to interest the heart in behalf of virtue, as much as any one has ever warped it to the side of vice, is a truth which no man will ever venture to call in question who has any knowledge of human na-

ture; and therefore we are decidedly of opinion, that there may be novels worthy at once of the perusal of inexperienced youth and hoary wisdom. A critic*, * *Johnson*. by no means too indulgent to works of fancy, and among whose failings laxity of morals has never been numbered, thus expresses himself on the subject of novel-writing:—"These familiar histories may perhaps be made of greater use than the solemnities of professed morality, and convey the knowledge of vice and virtue with more efficacy than axioms and definitions. But if the power of example is so great, as to take possession of the memory by a kind of violence, and produce effects almost without the intervention of the will, care ought to be taken, that, when the choice is unrestrained, the best examples only should be exhibited; and that what is likely to operate so strongly, should not be mischievous or uncertain in its effects."

We have said, that the novel professes above all things to exhibit the nature of love and its consequences. Whether this be essential to such performances may perhaps be reasonably questioned; but it has been made an important part of the drama in most novels, and, we think, with great propriety. It is the object of the novelist to give a true picture of life, diversified only by accidents that daily happen in the world, and influenced by passions and qualities which are really to be found in conversing with mankind. To accomplish this object, he conceives a hero or heroine, whom he places in a certain rank of life, endues with certain qualities of body and mind, and conducts, through many vicissitudes of fortune, either to the summit of happiness or to the abyss of misery, according to the passion which he wishes to excite in his readers. In the modern novel, this hero or heroine is never placed on a throne, or buried in a cottage; because to the monarch and the cottager no difficulties occur which can deeply interest the majority of readers. But among the virtuous part of the intermediate orders of society, that affection which we call *love* seldom fails, at some period of life, to take possession of the hearts of both sexes; and wherever it has place, it must be productive of happiness or of misery. In the proper management of this passion consists much of the difficulty of the novel-writer. He must exhibit his hero as feeling all the pangs and pleasures of love, as sometimes animated with hope, and sometimes ready to sink into despair, but always exerting himself to obtain the gratification of his wishes. In doing this, care should be taken, either that he never transgress the laws of virtue, or at least that he never transgress them with impunity.

"It is justly considered as the greatest excellency of art to imitate nature; but it is necessary to distinguish those parts of nature which are most proper for imitation: greater care is still required in representing life, which is so often discoloured by passion or deformed by wickedness. If the world be promiscuously described, I cannot perceive (says the great critic already quoted) of what use it can be to read the account; or why it may not be as safe to turn the eye immediately upon mankind, as upon a mirror which shows all that presents itself without discrimination. It is therefore not a sufficient vindication of a character, that it is drawn as it appears; for many characters

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characters ought never to be drawn: nor of a narrative, that the train of events is agreeable to observation; for that observation which is called knowledge of the world will be found much more frequently to make men cunning than good. The purpose of these writings is surely not only to show mankind, but to provide that they may be seen hereafter with less hazard; to teach the means of avoiding the snares which are laid by TREACHERY for INNOCENCE, without insuring any wish for that superiority with which the betrayer flatters his vanity; to give the power of counteracting fraud, without the temptation to practise it; to initiate youth by meek encounters in the art of necessary defence; and to increase prudence without impairing virtue.

"Many writers, for the sake of following nature, so mingle good and bad qualities in their principal personages, that they are both equally conspicuous; and as we accompany them through their adventures with delight, and are led by degrees to interest ourselves in their favour, we lose the abhorrence of their faults, because they do not hinder our pleasures, or perhaps regard them with some kindness for being united with so much merit.—There have been men indeed splendidly wicked, whose endowments threw a brightness on their crimes, and whom scarce any villany made perfectly detestable, because they never could be wholly divested of their excellencies: but such have been in all ages the great corrupters of the world; and their resemblance ought no more to be preserved than the art of murdering without pain.

"In narratives, where historical veracity has no place, there should be exhibited the most perfect idea of virtue; of virtue not angelical, nor above probability (for what we cannot credit we shall never imitate), but the highest and purest that humanity can reach, which, exercised in such trials as the various revolutions of things shall bring upon it, may, by conquering some calamities and enduring others, teach us what we may hope, and what we can perform. Vice (for vice is necessary to be shown) should always disgust; nor should the graces of gaiety, or the dignity of courage, be so united with it, as to reconcile it to the mind. Wherever it appears, it should raise hatred by the malignity of its practices, and contempt by the meanness of its stratagems; for while it is supported by either parts or spirit, it will seldom be heartily abhorred."

If these observations be just, and to us they appear unanswerable, Richardson's *Lovelace* is a character which ought never to have been drawn. In the graces of gaiety and the dignity of courage, in liberality without profusion, in perseverance and address, he every where appears as the first of men; and that honour with which he protects the virtue of his *Rosebud*, if any instruction is to be drawn from it, can only lead the admirers of Richardson to believe that another *Clarissa* might be in perfect safety were she to throw herself upon the honour of another *Lovelace*. Yet in the composition of this splendid character there is not one principle upon which confidence can securely rest; and *Lovelace*, whilst he is admired by the youth of both sexes, and escapes the contempt of all mankind, must excite in the breast of the cool moralist sentiments of abhorrence and detestation.

A French critic †, speaking of this character, says, "By turns I could embrace and fight with *Lovelace*. His pride, his gaiety, his drollery, charm and amuse me: his genius confounds me and makes me smile; his wickedness astonishes and enrages me; but at the same time I admire as much as I detest him." Surely this is not the character which ought to be presented to the inexperienced and ardent mind.

The most perfect characters which we at present recollect in any novel are Richardson's *Grandison* and Fielding's *Allworthy*. The virtues of the former are perhaps tinged with moral pedantry, if we may use the expression; and the latter suffered himself to be long imposed upon by the arts of the hypocrite and the philosophical coxcomb; but without some defects they would not be human virtues, and therefore no objects of human imitation. *Clarissa* is an excellent character: she has as much perfection as can be expected in woman, whilst she exhibits, at the same time, some obvious defects.

As it is the object of the novelist to interest the heart, and to communicate instruction through the medium of pleasure, his work, like a tragedy or comedy, should be one, exhibiting a hero or heroine, whose success every incident should contribute to forward or to retard. In this respect no work of fancy has ever surpassed the *Tom Jones* of Fielding. It is constructed upon principles of the soundest criticism, and contains not a single event which does not in some way contribute towards the winding up of the piece. A living author, deeply read in Grecian literature, and far from being prejudiced in behalf of any modern, has been heard to say, that had Aristotle seen *Tom Jones*, he would have pronounced it a poem perfect in its kind.

Against this sentence another critic of name has entered his protest, and strenuously maintained that nothing can be a poem which is not written in verse. We shall judge of the truth of this conclusion by comparing it with the principles from which it is deduced. Having laid down as a maxim incontrovertible, that "the end of poetry is pleasure, to which use itself must be subservient," he very justly infers from this IDEA, that "poetry should neglect no advantage that fairly offers itself, of appearing in such a dress or mode of language as is most taking and agreeable to us. It follows (he says), from the same idea of the end which poetry would accomplish, that not only rhythm, but NUMBERS properly so called, is essential to it, and that it cannot obtain its own purpose unless it be clothed in VERSE." He then proceeds to ask, "What, from this conclusion, are we to think of those novels or romances as they are called, which have been so current of late through all Europe? As they propose pleasure for their end, and prosecute it, besides, in the way of fiction, though without metrical numbers, and generally indeed in harsh and rugged prose, one easily sees what their pretensions are, and under what idea they are ambitious to be received. Yet as they are wholly destitute of measured sounds (to say nothing of their other numberless defects), they can at most be considered but as hasty, imperfect, and abortive poems: whether spawned from the dramatic or narrative species, it may be hard to say.

Novel.

† The author of *La jolie femme* or *La femme du jour*.

Novel.

Unfinished things, one knows not what to call,
Their generation's so equivocal.

However, such as they are, those *novelties* have been generally well received: *Some* for the real merit of their execution; *others*, for their amusing subjects; all of them, for the gratification they afford, or at least promise, to a vitiated, pallid, and sickly imagination, that last disease of learned minds, and sure prognostic of expiring letters. But whatever may be the temporary success of these things (for they vanish as fast as they are produced), good sense will acknowledge no work of art but such as is composed according to the laws of its kind."

Of this severe criticism the author himself has given us what amounts to a complete confutation. He tells us, that the ancients looked for so much force and spirit of expression in whatever they dignified with the name of *poem*, as sometimes to make a question "whether comedy were rightly referred to this class, because it differed only in measure from mere prose? Their doubt (he justly adds) might have been spared or at least resolved, if they had considered that comedy adopts as much of this force and spirit of words as is consistent with the nature and dignity of that pleasure which it pretends to give: For the name of *poem* will belong to every composition whose *primary* end is to please, provided it be so constructed as to afford *all* the pleasure which its kind or sort will permit."

If this decision be just, and we readily admit it, a well composed novel is intitled to the appellation of a *poem*, though it be written in prose and in a style not remarkable for elevation. The business of the novelist is to interest the heart by a display of the incidents of common life. In doing this, he must exhibit scenes that are probable, and record speeches that are natural. He is not at liberty to invent, but only to select, objects, and to call from the mass of mankind those individuals upon which the attention ought most to be employed. The more closely he adheres to this rule, the more deeply does he interest us in his narrative; because every reader sees at once that it is possible he may at some time or other be in circumstances nearly resembling those of the hero of the tale. But the business of life is not transacted in pompous language, nor the speeches of real lovers made in verse either rhimed or blank. Were *Tom Jones* or *Clarissa Harlowe* to be translated into verse, we shall venture to assert that they would quickly lose their hold of the public mind; because the hero and heroine would then appear in a light which every heart must feel to be unnatural.

It is well observed by Johnson, that the task of the novel writer "requires, together with that learning which is to be gained from books, that experience which can never be attained by solitary diligence, but must arise from general converse and accurate observation of the living world. Their performances have, as Horace expresses it, *plus oneris quantum varia minus*, little indulgence, and therefore more difficulty. They are engaged in portraits of which every one knows the original, and can detect any deviation from exactness of resemblance. Other writings are safe, except from the malice of learning, but these are in danger from every common reader; as the slipper ill executed

was censured by a shoemaker who happened to stop in his way at the Venus of Apelles." It is in thus faithfully copying nature that the excellence of Fielding consists. No man was ever better acquainted with the shades which diversifies characters, and none ever made his personages act and speak more like real men and women in the particular circumstances which he describes.

"But the fear of not being approved as a just copier of human manners, is not the most important concern that an author of this class ought to have before him. Novels are written chiefly to the young, the ignorant, and the idle, to whom they serve as lectures of conduct and introduction into life. In every such work, it should therefore be carefully inculcated, that virtue is the highest proof of understanding, and the only solid basis of greatness; and that vice is the natural consequence of narrow thoughts; that it begins in mistake, and ends in ignominy: and since love must be introduced, it should be represented as leading to wretchedness, whenever it is separated from duty or from prudence."

NOVEL, in the civil law, a term used for the constitutions of several emperors, more particularly those of Justinian. They were called *novels*, either from their producing a great alteration in the face of the ancient law, or because they were made on new cases, and after the revival of the ancient code.

NOVELTY, or NEWNESS. Of all the circumstances that raise emotions, not excepting beauty, nor even greatness, says Lord Kames*, novelty hath the most powerful influence. A new object produces instantaneously an emotion termed *wonder*, which totally occupies the mind, and for a time excludes all other objects. Conversation among the vulgar never is more interesting than when it turns upon strange objects and extraordinary events. Men tear themselves from their native country in search of things rare and new; and novelty converts into a pleasure the fatigues and even perils of travelling. To what cause shall we ascribe these singular appearances? To curiosity undoubtedly; a principle implanted in human nature for a purpose extremely beneficial, that of acquiring knowledge; and the emotion of wonder raised by new and strange objects, inflames our curiosity to know more of such objects. This emotion is different from *admiration*: novelty, wherever found, whether in a quality or action, is the cause of wonder; admiration is directed to the person who performs any thing wonderful.

During infancy, every new object is probably the occasion of wonder, in some degree; because, during infancy, every object at first sight is strange as well as new: but as objects are rendered familiar by custom, we cease by degrees to wonder at new appearances, if they have any resemblance to what we are acquainted with; for a thing must be singular as well as new, to raise our wonder. To save multiplying words, we would be understood to comprehend both circumstances when we hereafter talk of novelty.

In an ordinary train of perceptions where one thing introduces another, not a single object makes its appearance unexpectedly: the mind thus prepared for the reception of its objects, admits them one after another without perturbation. But when a thing breaks in unexpectedly, and without the preparation of any

Novel,
Novelty.

* *Elements of Criticism.*

Novelty. connection, it raises an emotion, known by the name of *surprise*. That emotion may be produced by the most familiar object, as when one unexpectedly meets a friend who was reported to be dead; or a man in high life, lately a beggar. On the other hand, a new object, however strange, will not produce the emotion, if the spectator be prepared for the sight: an elephant in India will not surprise a traveller who goes to see one; and yet its novelty will raise his wonder: an Indian in Britain would be much surprised to stumble upon an elephant feeding at large in the open fields; but the creature itself, to which he was accustomed, would not raise his wonder.

Surprise thus in several respects differs from wonder: unexpectedness is the cause of the former emotion; novelty is the cause of the latter. Nor differ they less in their nature and circumstances, as will be explained by and by. With relation to one circumstance they perfectly agree; which is, the shortness of their duration: the instantaneous production of these emotions in perfection, may contribute to that effect, in conformity to a general law, That things soon decay which soon come to perfection: the violence of the emotions may also contribute; for an ardent emotion, which is not susceptible of increase, cannot have a long course. But their short duration is occasioned chiefly by that of their causes: we are soon reconciled to an object, however unexpected; and novelty soon degenerates into familiarity.

Whether these emotions be pleasant or painful, is not a clear point. It may appear strange, that our own feelings and their capital qualities should afford any matter for a doubt: but when we are engrossed by any emotion, there is no place for speculation; and when sufficiently calm for speculation, it is not easy to recal the emotion with accuracy. New objects are sometimes terrible, sometimes delightful: the terror which a tyger inspires is greatest at first, and wears off gradually by familiarity: on the other hand, even women will acknowledge that it is novelty which pleases the most in a new fashion. It would be rash however to conclude, that wonder is in itself neither pleasant nor painful, but that it assumes either quality according to circumstances. An object, it is true, that hath a threatening appearance, adds to our terror by its novelty: but from that experiment it doth not follow, that novelty is in itself disagreeable; for it is perfectly consistent, that we be delighted with an object in one view, and terrified with it in another. A river in flood swelling over its banks, is a grand and delightful object; and yet it may produce no small degree of fear when we attempt to cross it: courage and magnanimity are agreeable; and yet, when we view these qualities in an enemy, they serve to increase our terror. In the same manner, novelty may produce two effects clearly distinguishable from each other: it may, directly and in itself, be agreeable; and it may have an opposite effect indirectly, which is, to inspire terror; for when a new object appears in any degree dangerous, our ignorance of its powers and faculties affords ample scope for the imagination to dress it in the most frightful colours. The first sight of a lion, for example, may at the same instant produce two opposite feelings, the pleasant emotion of wonder, and the painful passion of terror: the novelty of the object pro-

duces the former directly, and contributes to the latter indirectly. Thus, when the subject is analysed, we find that the power which novelty hath indirectly to inflame terror, is perfectly consistent with its being in every circumstance agreeable. The matter may be put in the clearest light, by adding the following circumstance. If a lion be first seen from a place of safety, the spectacle is altogether agreeable without the least mixture of terror. If, again, the first sight puts us within reach of that dangerous animal, our terror may be so great as quite to exclude any sense of novelty. But this fact proves not that wonder is painful: it proves only, that wonder may be excluded by a more powerful passion. Every man may be made certain from his own experience, that wonder raised by a new object that is inoffensive, is always pleasant; and with respect to offensive objects, it appears, from the foregoing deduction, that the same must hold as long as the spectator can attend to the novelty.

Whether surprise be in itself pleasant or painful, is a question not less intricate than the former. It is certain that surprise inflames our joy when unexpectedly we meet with an old friend; and not less our terror when we stumble upon any thing noxious. To clear that question, the first thing to be remarked is, that in some instances an unexpected object overpowers the mind, so as to produce a momentary stupefaction: where the object is dangerous, or appears so, the sudden alarm it gives, without preparation, is apt totally to unhinge the mind, and for a moment to suspend all its faculties, even thought itself; in which state a man is quite helpless; and if he move at all, is as like to run upon the danger as from it. Surprise carried to such a height, cannot be either pleasant or painful; because the mind, during such momentary stupefaction, is in a good measure, if not totally, insensible.

If we then inquire for the character of this emotion, it must be where the unexpected object or event produceth less violent effects. And while the mind remains sensible of pleasure and pain, is it not natural to suppose, that surprise, like wonder, should have an invariable character? It would appear, however, that surprise has no invariable character, but assumes that of the object which raises it. Wonder being an emotion invariably raised by novelty, and being distinguishable from all other emotions, ought naturally to possess one constant character. The unexpected appearance of an object, seems not equally intitled to produce an emotion distinguishable from the emotion, pleasant or painful, that is produced by the object in its ordinary appearance: the effect it ought naturally to have, is only to swell that emotion, by making it more pleasant or more painful than it commonly is. And that conjecture is confirmed by experience, as well as by language which is built upon experience: when a man meets a friend unexpectedly, he is said to be agreeably surprised; and when he meets an enemy unexpectedly, he is said to be disagreeably surprised. It appears, then, that the sole effect of surprise is to swell the emotion raised by the object. And that effect can be clearly explained: a tide of connected perceptions glide gently into the mind, and produce no perturbation; but an object breaking in unexpectedly, sounds an alarm, rouses the mind out of its calm state, and directs

Novelty. its whole attention to the object, which, if agreeable, becomes doubly so. Several circumstances concur to produce that effect: on the one hand, the agitation of the mind and its keen attention prepare it in the most effectual manner for receiving a deep impression: on the other hand, the object, by its sudden and unforeseen appearance, makes an impression, not gradually as expected objects do, but as at one stroke with its whole force. The circumstances are precisely similar where the object is in itself disagreeable (A).

The pleasure of novelty is easily distinguished from that of variety: to produce the latter, a plurality of objects is necessary; the former arises from a circumstance found in a single object. Again, where objects, whether coexistent or in succession, are sufficiently diversified, the pleasure of variety is complete, though every single object of the train be familiar; but the pleasure of novelty, directly opposite to familiarity, requires no diversification.

There are different degrees of novelty, and its effects are in proportion. The lowest degree is found in objects surveyed a second time after a long interval; and that in this case an object takes on some appearance of novelty, is certain from experience: a large building of many parts variously adorned, or an extensive field embellished with trees, lakes, temples, statues, and other ornaments, will appear new oftener than once: the memory of an object so complex is soon lost, of its parts at least, or of their arrangement. But experience teaches, that, even without any decay of remembrance, absence alone will give an air of novelty to a once familiar object; which is not surprising, because familiarity wears off gradually by absence: thus a person with whom we have been intimate, returning after a long interval, appears like a new acquaintance. And distance of place contributes to this appearance, not less than distance of time: a friend, for example, after a short absence in a remote country, has the same air of novelty as if he had returned after a longer interval from a place nearer home:

the mind forms a connection between him and the remote country, and bestows upon him the singularity of the objects he has seen. For the same reason, when two things equally new and singular are presented, the spectator balances between them; but when told that one of them is the product of a distant quarter of the world, he no longer hesitates, but clings to it as the more singular: hence the preference given to foreign luxuries, and to foreign curiosities, which appear rare in proportion to their original distance.

The next degree of novelty, mounting upward, is found in objects of which we have some information at second hand; for description, though it contribute to familiarity, cannot altogether remove the appearance of novelty when the object itself is presented: the first sight of a lion occasions some wonder, after a thorough acquaintance with the correctest pictures and statues of that animal.

A new object that bears some distant resemblance to a known species, is an instance of a third degree of novelty: a strong resemblance among individuals of the same species, prevents almost entirely the effect of novelty, unless distance of place or some other circumstance concur; but where the resemblance is faint, some degree of wonder is felt, and the emotion rises in proportion to the faintness of the resemblance.

The highest degree of wonder ariseth from unknown objects that have no analogy to any species we are acquainted with. Shakespeare in a simile introduces that species of novelty:

As glorious to the sight
As is a winged messenger from heaven
Unto the white up-turned wond'ring eye
Of mortals, that fall back to gaze on him
When he bestrides the lazy-pacing clouds
And sails upon the bosom of the air.

Romeo and Juliet.

One example of that species of novelty deserves peculiar attention; and that is, when an object altogether new is seen by one person only, and but once.

2

These

(A) What the Mareschal Saxe terms *le cœur humain*, is no other than fear occasioned by surprise. It is owing to that cause that an ambush is generally so destructive: intelligence of it beforehand renders it perfectly harmless. The Mareschal gives from Cæsar's Commentaries two examples of what he calls *le cœur humain*. At the siege of Amiens by the Gauls, Cæsar came up with his army, which did not exceed 7000 men; and began to entrench himself in such hurry, that the barbarians, judging him to be afraid, attacked his entrenchments with great spirit. During the time they were filling up the ditch, he issued out with his cohorts, and by attacking them unexpectedly struck a panic that made them fly with precipitation, not a single man offering to make a stand. At the siege of Alesia, the Gauls infinitely superior in number attacked the Roman lines of circumvallation, in order to raise the siege. Cæsar ordered a body of his men to march out silently, and to attack them on the one flank, while he with another body did the same on the other flank. The surprise of being attacked when they expected a defence only, put the Gauls into disorder, and gave an easy victory to Cæsar.

A third may be added not less memorable. In the year 846, an obstinate battle was fought between Xamir king of Leon and Abdoulrahman the Moorish king of Spain. After a very long conflict, the night only prevented the Arabians from obtaining a complete victory. The king of Leon, taking advantage of the darkness, retreated to a neighbouring hill, leaving the Arabians masters of the field of battle. Next morning, perceiving that he could not maintain his place for want of provisions, nor be able to draw off his men in the face of a victorious army, he ranged his men in order of battle, and, without losing a moment, marched to attack the enemy, resolving to conquer or die. The Arabians, astonished to be attacked by those who were conquered the night before, lost all heart: fear succeeded to astonishment, the panic was universal, and they all turned their backs without almost drawing a sword.

Novelty. These circumstances heighten remarkably the emotion: the singularity of the spectator concurs with the singularity of the object, to inflame wonder to its highest pitch.

In explaining the effects of novelty, the place a being occupies in the scale of existence, is a circumstance that must not be omitted. Novelty in the individuals of a low class is perceived with indifference, or with a very slight emotion: thus a pebble, however singular in its appearance, scarce moves our wonder. The emotion rises with the rank of the object; and, other circumstances being equal, is strongest in the highest order of existence; a strange insect affects us more than a strange vegetable; and a strange quadruped more than a strange insect.

However natural novelty may be, it is a matter of experience, that those who relish it the most are careful to conceal its influence. Love of novelty, it is true, prevails in children, in idlers, and in men of shallow understanding: and yet, after all, why should one be ashamed of indulging a natural propensity? A distinction will afford a satisfactory answer. No man is ashamed of curiosity when it is indulged to acquire knowledge. But to prefer any thing merely because it is new, shows a mean taste which one ought to be ashamed of: vanity is commonly at the bottom, which leads those who are deficient in taste to prefer things odd, rare, or singular, in order to distinguish themselves from others. And in fact, that appetite, as above-mentioned, reigns chiefly among persons of a mean taste, who are ignorant of refined and elegant pleasures.

Of this taste we have some memorable instances in men of the highest and the best education. Lucian tells the following story of Ptolemy I. which is as disgraceful to him, as honourable to his subjects. This prince had ransacked the world for two curiosities: one was a camel from Bactria all over black; the other a man, half black half white. These he presented to the people in a public theatre, thinking they would give them as much satisfaction as they did him; but the black monster, instead of delighting them, affrighted them; and the party-coloured man raised the contempt of some and the abhorrence of others. Ptolemy, finding the Egyptians preferred symmetry and beauty to the most astonishing productions of art or nature without them, wisely removed his two enormous trifles out of sight; the neglected camel died in a little time, and the man he gave for a song to the musician Thespis.

One final cause of wonder, hinted above, is, that this emotion is intended to stimulate our curiosity. Another, somewhat different, is, to prepare the mind for receiving deep impressions of new objects. An acquaintance with the various things that may affect us, and with their properties, is essential to our well-being: nor will a slight or superficial acquaintance be sufficient; they ought to be so deeply engraved on the mind, as to be ready for use upon every occasion. Now, in order to a deep impression, it is wisely contrived, that things should be introduced to our acquaintance with a certain pomp and solemnity productive of a vivid emotion. When the impression is once fairly made, the emotion of novelty being no longer necessary, vanisheth almost instantaneously; never to

return, unless where the impression happens to be obliterated by length of time or other means; in which case the second introduction hath nearly the same solemnity with the first.

Designing wisdom is nowhere more eligible than in this part of the human frame. If new objects did not affect us in a very peculiar manner, their impressions would be so slight as scarce to be of any use in life: on the other hand, did objects continue to affect us as deeply as at first, the mind would be totally engrossed with them, and have no room left either for action or reflection.

The final cause of surprise is still more evident than of novelty. Self-love makes us vigilantly attentive to self-preservation; but self-love, which operates by means of reason and reflection, and impels not the mind to any particular object or from it, is a principle too cool for a sudden emergency; an object breaking in unexpectedly, affords no time for deliberation; and in that case, the agitation of surprise comes in seasonably to rouse self-love into action: surprise gives the alarm; and if there be any appearance of danger, our whole force is instantly summoned to shun or to prevent it.

NOVELLARA, a handsome town of Italy, and capital of a small district of the same name, with a handsome castle, where their sovereign resides. E. Lon. 10. 37. N. Lat. 45. 50.

NOVEMVIRI, nine magistrates of Athens, whose government lasted but for one year. The first of whom was called *archon*, or prince; the second *bafilus*, or king; the third *polemarchus*, or general of the army: the other six were called *thesmothetae*, or lawgivers. They took an oath to observe the laws; and in case of failure, obliged themselves to bestow upon the commonwealth a statue of gold as big as themselves. Those who discharged their office with honour, were received into the number of the senators of Areopagus.

NOVI, a town of Italy, in the territory of Genoa, on the confines of the Milanese. It was taken by the Piedmontese in 1746. E. Long. 8. 48. N. Lat. 44. 45.

Novi Bazar, a considerable town of Turkey in Europe, and in Servia, near the river Oresco. E. Long. 20. 24. N. Lat. 43. 25.

NOVICE, a person not yet skilled or experienced in an art or profession.

In the ancient Roman militia, *novicii*, or *novitii*, were the young raw soldiers, distinguished by this appellation from the veterans.

In the ancient orders of knighthood, there were novices, or clerks in arms, who went through a kind of apprenticeship ere they were admitted knights.—See KNIGHT.

NOVICE is more particularly used in monasteries for a religious yet in his, or her, year of probation, and who has not made the vows.

In some convents, the sub-prior has the direction of the novices. In nunneries, the novices wear a white veil; the rest a black one.

NOVICIATE, a year of probation appointed for the trial of religious, whether or no they have a vocation, and the necessary qualities for living up to the rule; the observation whereof they are to bind themselves

Novellara
||
Noviciate.

Novigrad selves to by vow. The noviciate lasts a year at least ; in some houses more. It is esteemed the bed of the civil death of a novice, who expires to the world by profession.

Novogorod.

NOVIGRAD, a small but strong town of Upper Hungary, capital of a county of the same name, with a good castle, seated on a mountain near the Danube, E. Long. 18. 10. N. Lat. 40. 50.

NOVIGRAD, a small but strong town of Dalmatia, with a castle, and subject to the Turks ; seated on a lake of the same name, near the gulph of Venice. E. Long. 16. 45. N. Lat. 44. 30.

NOVIGRAD, a very strong place of Servia, subject to the Turks ; seated near the Danube. E. Long. 26. 5. N. Lat. 45. 5.

NOVIODUNUM (Cæsar), a town of the Ædui, commodiously seated on the Liguris: the *Nivernum* of Antonine. Now *Newers* in the Orleanois, on the Loire.—A second *Noviodunum* of the Auleri Diablintes, in Gallia Celtica, (Antonine) ; called *Noviodunum* (Ptolemy), and *Noningentum Rotrudum* by the moderns: *Nogente le Rotrou*, capital of the duchy of Perche.—A third of the Bituriges, (Cæsar) : Now *Nueve sur Baranion* ; a village 15 miles to the north of Bourges, towards Orleans.—A fourth, of Mæsia Inferior, (Ptolemy), situated on the Ister: now *Nivorz*, in Bessarabia.—A fifth, of Pannonia Superior, (Antonine) ; now *Gurksfeld* in Carinthia.—A sixth, *Noviodunum Sueffionum*, the same with *Augusta Sueffionum*.—A seventh, *Noviodunum* of the Veromandui in Gallia Belgica, (Cæsar) : now *Noyon* in the Isle of France, on the borders of Picardy.

NOUN, see GRAMMAR, n^o 7. ; and chapter 1st in toto.

NOVOGOROD WELICKI, or *Great Novogorod*, according to Mr Coxe, is one of the most ancient cities in Russia. It was formerly called *Great Novogorod*, to distinguish it from other Russian towns of a similar appellation ; and now presents to the attentive and intelligent traveller a striking instance of fallen grandeur. According to Nestor, the earliest of the Russian historians, it was built at the same time with Kiof, namely, in the middle of the 5th century, by a Sclavonian horde, who, according to Procopius, issued from the banks of the Volga. Its antiquity is clearly proved by a passage in the Gothic historian Jornandes, in which it is called *Civitas Nova*, or new town. We have little insight into its history before the ninth century, when Ruric the first great-duke of Russia reduced it, and made it the metropolis of his vast dominion. The year subsequent to his death, which happened in 879, the seat of government was removed, under his son Igor, then an infant, to Kiof ; and Novogorod continued, for above a century, under the jurisdiction of governors nominated by the great-dukes, until in 970, when Svatoflaf, the son of Igor, created his third son Vladimir duke of Novogorod : the latter, succeeding his father in the throne of Russia, ceded the town to his son Yaroflaf, who in 1036 granted to the inhabitants very considerable privileges, that laid the foundation of that extraordinary degree of liberty which they afterwards gradually obtained. From this period Novogorod was for a long time governed by its own dukes : these sovereigns were at first subordinate

N^o 244.

to the great-dukes, who resided at Kiof and Volodimir ; but afterwards, as the town increased in population and wealth, they gradually usurped an absolute independency. Its independency, however, was not perpetual. It continued, indeed, in a flourishing state until the middle of the 15th century : but the great-dukes of Russia, whose ancestors had reigned over this town, and who still retained the title of dukes of Novogorod, having transferred their residence from Kiof to Volodimir, and afterwards to Moscow, laid claim to its feudal sovereignty ; a demand which the inhabitants sometimes put off by composition, sometimes by resistance, but were sometimes compelled to acknowledge. At length, however, the great-duke became absolute sovereign of Novogorod, though the ostensible forms of government were still preserved. It even then, however, continued to be the largest and most commercial city of Russia ; a proof of which we have as late as the year 1554, from the following description of Richard Chancellor, who passed through it in 1554 in his way to Moscow. " Next unto Moscow, the city of Novogorod is reputed the chiefest of Russia ; for although it be in majesty inferior to it, yet in greatness it goeth beyond it. It is the chiefest and greatest mart town of all Muscovy ; and albeit the emperor's seat is not there, but at Moscow, yet the commodiousness of the river, falling into that gulph which is called Sinus Finnicus, whereby it is well frequented by merchants, makes it more famous than Moscow itself." An idea of its population during this period, when compared with its present declined state, is manifest from the fact, that in 1508 above 15,000 persons died of an epidemical disorder ; more than double the number of its present inhabitants. In its most flourishing condition it contained at least 400,000 souls. Its ruin was brought on by Ivan Vasilievitch II. and completed by the foundation of Petersburg. The present town is surrounded by a rampart of earth, with a range of old towers at regular distances, forming a circumference of scarcely a mile and an half ; and even this inconsiderable circle includes much open space, and many houses which are not inhabited. As Novogorod was built after the manner of the ancient towns of this country in the Asiatic style, this rampart, like that of the Semlainogorod at Moscow, probably inclosed several interior circles. Without it was a vast extensive suburb, which reached to the distance of six miles, and included within its circuit all the convents and churches, the ancient ducal palace and other structures, that now make a splendid but solitary appearance, as they lie scattered in the adjacent plain.

Novogorod stretches on both sides of the Volkof, a beautiful river of considerable depth and rapidity, and somewhat broader than the Thames at Windsor. This river separates the town into two divisions, the trading part, and the quarter of St Sophia, which are united by means of a bridge, partly wooden and partly brick.

NOVOGOROD Welicki, a province of Moscow, bounded on the north by Ingria ; on the east by part of the duchy of Belozero, and that of Tuera, which also bounds it on the south, with the province of Rzeva ; and on the west by Plescow. It is full of lakes and forests ;

Novogorod.

Novogorod forests; however, there are some places which produce corn, flax, hemp, honey, and wax.

Noyon.

NOVOGOROD Serpyskoi, a strong town of the Russian empire, and capital of a province of Siberia of the same name, seated on the river Dubica, in E. Long. 33. 20. N. Lat. 52. 30.

NOVOGORODECK, a town of Lithuania, and capital of a palatinate of the same name. It is a large place, and situated in a vast plain, in E. Long. 25. 30. N. Lat. 53. 45.

NOURISHMENT. See **NUTRITION.**

NOURISHMENT of Vegetables. See **AGRICULTURE**, Part I. Sect. 1. and 2. and **PLANTS**; also the article **COMPOSTS.**

NOWED, in heraldry, signifies "knotted," from the Latin *nodatus*; being applied to the tails of such creatures as are very long, and sometimes represented in coat-armour as tied up in a knot.

NOX (fab. hist.), one of the most ancient deities among the heathens, daughter of Chaos. From her union with her brother Erebus, she gave birth to the Day and the Light. She was also the mother of the Paræ, Hesperides, Dreams, of Discord, Death, Momus, Fraud, &c. She is called by some of the poets the mother of all things, of gods as well as of men; and she was worshipped with great solemnity by the ancients. She had a famous statue in Diana's temple at Ephesus. It was usual to offer her a black sheep, as she was the mother of the Furies. The cock was also offered to her, as that bird proclaims the approach of day during the darkness of the night. She is represented as mounted on a chariot, and covered with a veil bespangled with stars. The constellations generally went before her as her constant messengers. Sometimes she is seen holding two children under her arms; one of which is black representing Death, and the other white representing Sleep. Some of the moderns have described her as a woman veiled in mourning, and crowned with poppies, and carried on a chariot drawn by owls and bats.

NOYON is a town in France, situated on the declivity of a hill of an easy descent, on the rivulet Vorfe, which at a quarter of a league's distance falls into the Oyse, in the isle of France, in E. Long. 3°, N. Lat. 49° 38', about 66 miles north-east of Paris. It is an ancient place, being the *Noviodunum Belgarum* of the Latins. It is a pretty large city, and is well situated for inland trade, which consists here in wheat and oats, which they send to Paris. They have also manufactories of linen-cloths, lawns, and tanned leather. There are eight parishes in it, two abbeys, and several monasteries of both sexes. It is the see of a bishop suffragan to the metropolitan of Rheims; he has the title of count and peer of France, and his income is said to amount to about 15,000 livres *per annum*. The principal buildings are the episcopal palace, a cloister where the canons of the cathedral dwell, and the town-house. The latter is regularly built in a large square, in the middle of which there is a fountain, where the water conveyed to it from a neighbouring mountain, runs continually through three conduits, and is received in a large basin built of very hard stone. They have also many other fountains, several market-places, and two public gardens. Noyon is particularly remark-

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able for the birth of the famous John Calvin, who was born here the 10th of July 1502, and died at Geneva the 27th of May 1564.

Nuayhas, Nuba.

NUAYHAS, the **AGUE-TREE**; a name given by the Indians to a sort of Bamboo cane, the leaves of which falling into the water, are said to impregnate it with such virtue, that the bathing in it afterwards will cure the ague. They use also a decoction of the leaves to dissolve coagulated blood, giving it internally, and at the same time rubbing the bruised part externally with it. It is said that this plant bears its flowers only once in its life; that it lives 60 years before those make their appearance; but that when they begin to show themselves, it withers away in about a month afterwards; that is, as soon as it has ripened the seed. There seems to be something of fiction in the account of many other particulars relating to this tree in the *Hortus Malabaricus*; but it seems certain, that the length of the stalks, or trunk, must be very great: for, in the gallery of Leyden, there is preserved a cane of it 28 feet long; and another not much shorter in the Ashmolean museum at Oxford, and which is more than eight inches in diameter: yet both these appear to be only parts of the whole trunk, they being nearly as large at one end as at the other.

NUBA, a race of black Pagans, in the neighbourhood of Sennaar, of whom we know nothing but what we have learned from Mr Bruce. That celebrated traveller passed a day or two among them, in his way from Abyssinia; and he tells us, that they are all soldiers of the *Mek* or king of Sennaar, cantoned in villages, which to the distance of four or five miles surround the capital. They are not the aborigines of that part of Africa; but "are either purchased or taken by force from Fazulco, and the provinces to the south upon the mountains Dyre and Tegle." Though the slaves of a cruel and treacherous master, Mr Bruce represents them as a gentle, honest, and hospitable people; and he says expressly, that on a journey he had seldom passed a more comfortable night, than one in which he took refuge from a storm in a village of those Nuba. He had a good supper, and a clean neat hut to sleep in, while some of the Nuba watched for him all night, and took care of his beasts and his baggage. "Having settlements and provisions given them by the government of Sennaar, as also arms put into their hands, they never wish to desert, but live a very domestic and sober life, and are a much gentler sort of negro than their masters." (See **SENNAAR**.) Tho' the established religion of Sennaar is that of Mahomet, the government has never attempted to convert the Nuba. On the contrary, a certain number of Pagan priests is maintained for them in every village, who have soldiers in pay to assist them in the affairs of their religion. This is a very singular instance of toleration among Mahometans, and what we should little have expected from such barbarous and sanguinary wretches as those who have the supreme power in Sennaar, had not our observing traveller informed us, that these men themselves know almost nothing of the religion which they profess, and are in their hearts rather Pagans than Mahometans.

The idolatry of the Nuba is described as a mixture of Sabiism and statue worship; but what is very un-

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common, their worship is chiefly paid to the moon, while they pay no attention to the sun either rising or setting, advancing to the meridian or receding from it. It is an old observation, that the worship of every people is tinged by their natural dispositions; and this is verified in the Nuba. "That their worship is performed with pleasure and satisfaction, is obvious (says our author) every night that the moon shines. Coming out from the darkness of their huts, they say a few words upon seeing her brightness, and testify great joy, by motions of their feet and hands, at the first appearance of the new moon." This is just what we should have expected from their gentleness and hospitality. They worship likewise a tree and a stone: but our author could never discover what tree or stone; only he learned that neither of them exists in Sennaar, but in the country where the Nuba are born. Such of them as are natives of the villages where he saw them, become, like their masters, nominal Mahometans.—The rest practise the idolatrous worship of their ancestors, and are much under the influence of their priests, from fear rather than from affection. They are immoderately fond of swine's flesh, and maintain great herds of small hogs, marked with black and white spots. Few of the Nuba advance higher than to be soldiers and officers in their own corps; and the Mek maintains about 12,000 of them near Sennaar to keep the Arabs in subjection. In a climate so violent as that which they inhabit, there is very little need of fuel; and it is happy for them that such is the case, for in the whole country there is not a single tree, nor turf, nor any thing resembling it. They do not, however, "eat their meat raw like the Abyssinians; but with the stalk of the dora or millet, and the dung of camels, they make ovens under ground, in which they roast their hogs whole, in a very cleanly manner, keeping the skins on till they are perfectly baked. They have neither flint nor steel with which to light their fire at first; but do it in a manner still more expeditious, by means of two sticks, brought, we are led to think, from Sennaar, and there picked out of the river when flooded. They make a small hole in one of these sticks, and point the other: then laying the former in a horizontal position, they apply the point of the latter to the hole; and, turning the perpendicular stick between their hands, as we do a chocolate-mill, both sticks take fire and flame in a moment; so perfectly dry and prepared to take fire is every thing there on the surface of the earth."

NUBECULA, LITTLE CLOUD, in medicine, a term sometimes used for a disease in the eye, wherein objects appear as through a cloud or mist.

The nubecula seems to arise from certain gross particles detained in the pores of the cornea, or swimming in the aqueous humour, and thus intercepting the rays of light.

NUBECULA, or *Nubes*, is also used for what we otherwise call *albugo*. See ALBUGO.

NUBECULA is used likewise for a matter in form of a cloud, suspended in the middle of the urine.

NUBIA, a kingdom of Africa, bounded on the north by Egypt, on the east by the Red Sea and part of Abyssinia, on the west by the kingdoms of Tagua, Gaoga, and the desert of Gerham. The river Nile runs through it; on the banks of which, and those of

the other rivers, it is pretty fruitful, but in other places barren, sandy, and in want of water. To the west of the Nile is the desert of Bahouda, which is five days journey over, being the usual road from Egypt to Abyssinia. Money is of no use in this country in the way of trade, it being all carried on by way of exchange. Their bread and drink is made of a small round seed, called *doca* or *seff*, which is very ill tasted. Their houses have mud walls, being very low, and covered with reeds. The habit of the better sort is a vest without sleeves; and they have no coverings for their heads, legs, and feet. The common people wrap a piece of linen cloth about them, and the children go quite naked. They are a stupid debauched sort of people, having neither modesty, civility, nor religion, though they profess to be Mahometans.—The productions of this country are gold, elephants teeth, civet, and sandal wood; and they send a great many slaves into Egypt. The principal towns known to the Europeans are Dangola and Sennaar.

It is famous for a race of horses the most powerful and docile in the world. These animals are generally about 16 hands high; and by Mr Bruce, who has given the most scientific account of them, they are said to be the breed which was introduced into Nubia at the Saracen conquest, and has been preserved unmixed to this day. Our author represents this as a much nobler animal than the Arabian horse. "What figure (says he *) the Nubian horse would make in point of fleetness is very doubtful, his make being so entirely different from that of the Arabian; but if beautiful symmetry of parts, great size and strength, the most agile, nervous, and elastic movements, great endurance of fatigue, docility of temper, and seeming attachment to men beyond that of any other domestic animal, can promise any thing for a stallion, the Nubian is above all comparison the most eligible in the world." He thinks, and justly thinks, that an attempt should at least be made to import them into this kingdom. "The expence (he says) would not be great, though there might be some trouble and application necessary; but if adroitly managed, there would not be much even of that. The Nubians are very jealous in keeping up the pedigree of their horses, which are black or white, but a vast proportion of the former to the latter." Our author never saw the colour which we call grey, *i. e.* dappled; but he has seen some bright bays, and some inclining to sorrel. All noble horses in Nubia are said to be descended of one of the five upon which Mahomet and his four immediate successors, Abu Beer, Omar, Atmen, and Ali, fled from Mecca to Medina the night of the Hegira. No one will pay much regard to this legendary tale, or believe that the strength and beauty of this breed of horses is owing to any virtue communicated to the first of them by the prophet and his apostles. Mr Bruce accounts for their excellence upon rational principles. "The best horses of the Arabian breed are found (he says) in the tribe of Mowelli and Annecy, which is about 36° north latitude. Dongala, which is in 20° latitude, seemed to him to be the centre of excellence for this noble animal." Hence he infers, that the bounds in which the horse is in greatest perfection, are between the 20th and 36th degrees of latitude, and between 30 degrees of longitude east from Greenwich.

Nubia.

* *Travels*,
vol. iv. B. 8.
ch. 10.

Nubian Desert. Greenwich and the banks of the Euphrates. If to the effects of climate we add the manner of feeding the Nubian horses, we shall perhaps have the true cause of their superiority over all others. "They are kept fat upon dora, and suffered to eat nothing green but the short roots of grass that are to be found by the side of the Nile, after the sun has withered it. This is dug out where it is covered with earth, and appears blanched, and laid in small heaps once a-day on the ground before them."

NUBIAN DESERT, a vast tract of barren rocks and burning sands, extending from Syene in Upper Egypt to Geon the capital of Berber in Nubia. As Syene is in latitude $24^{\circ} 0' 45''$ north, and Geon in latitude $17^{\circ} 57' 22''$, the length of this desert from north to south is $6^{\circ} 3' 23''$, or upwards of 420 English miles. Its breadth from east to west has not, as far as we know, been precisely ascertained. Through this horrid region, where nothing is to be seen which has the breath of life, must all travellers pass from Sennaar to Egypt; in danger every moment of perishing by thirst, being overwhelmed by moving columns of sand, suffocated by a hot and poisonous wind, or cut in pieces by troops of wandering Arabs. The last European of whom we have heard that made the journey and lived to give an account of it, is Mr Bruce; and the person must have neither taste nor sensibility who can read unmoved his manly narrative.

No single traveller, nor even a caravan, can enter with safety into this desert, but under the protection of a Hybear; whose title and office are thus explained by Mr Bruce: "A Hybear is a guide, from the Arabic word *Hubbar*, which signifies to inform, instruct, or direct, because they are used to do this office to the caravans travelling through the desert in all directions. They are men of great consideration, knowing perfectly the situation and properties of all kinds of water to be met with on the route, the distance of wells, whether occupied by enemies or not; and if so, the way to avoid them with the least inconvenience. It is also necessary that they should know the places occupied by the Simoom, and the seasons of its blowing (see *SIMOOM*), as well as those occupied by moving sands."—Under the conduct of one of these men, Mr Bruce, with infinite fortitude and address, passed through the desert in the year 1772, surmounting dangers at which one shudders in his closet. Of these, the following, which we shall give in the nervous language of the author, may serve as an instance.

"We were here (at a place called *Weadi al Halboub*) at once surprised and terrified by a sight surely one of the most magnificent in the world. In that vast expanse of desert, from W. and to N. W. of us, we saw a number of prodigious pillars of sand at different distances, at times moving with great celerity, at others stalking on with a majestic slowness. At intervals we thought they were coming in a very few minutes to overwhelm us; and small quantities of sand did actually more than once reach us. Again, they would retreat so as to be almost out of sight; their tops reaching to the very clouds. There the tops often separated from the bodies; and these once disjoined, dispersed in the air, and did not appear more. Sometimes they were broken in the middle as if struck with a large cannon shot. About noon they began to advance with considerable

swiftness upon us, the wind being very strong at north. Eleven of them ranged alongside of us about the distance of three miles. The greatest diameter of the largest appeared to me at that distance as if it would measure 10 feet. They retired from us with a wind at S. E. leaving an impression upon my mind to which I can give no name; though surely one ingredient in it was fear, with a considerable degree of wonder and astonishment."

If it be true, as the author of *A Philosophical Inquiry into the Origin of our Ideas of the Sublime and Beautiful* affirms, that "the passion raised by the sublime is astonishment, and that astonishment is that state of the soul in which all its motions are suspended with some degree of horror," surely a more sublime spectacle was never presented to mortal eyes, than that which was on this occasion presented to Mr Bruce. It must have been awfully majestic; but few, we believe, would choose the pleasure of contemplating such a scene of magnificence at the hazard of that dreadful death with which, at every moment it threatened our traveller and his attendants. He, indeed, had firmness of mind to stand still and admire it; but his companions shrieked out; while some of them exclaimed that it was the day of judgment, and others that it was hell or the world set on fire. But for a more particular account of this phenomenon, as well as of the nature of the desert and the proper way of passing it, we must refer to the work from which this short sketch is taken*.

NUCLEUS, in general, denotes the kernel of a nut, or even any seed inclosed within a husk. The term *nucleus* is also used for the body of a comet, otherwise called its *head*. * Bruce's Travels, vol. iv.

NUCTA, a dew, which falling in Egypt about St John's day, is by the superstitious natives of the country considered as miraculous, and the peculiar gift of that saint. Its effects are indeed so beneficial, that this belief is little surprising among a people so totally ignorant of natural causes as the modern Egyptians; for it is acknowledged, by the most enlightened travellers, to stop the plague, and announce a speedy and plentiful inundation of the country. These effects are thus rationally accounted for by Mr Bruce.

"In February and March, the sun is on its approach to the zenith of one extremity of Egypt, and of course has a very considerable influence upon the other. The Nile having now fallen low, the water in certain old cisterns, which, though they still exist, are suffered to accumulate all the filth of the river, becomes putrid, and the river itself has lost all its finer and volatile parts by the continued action of a vertical sun; so that instead of being subject to evaporation, it grows daily more and more inclined to putrefaction. About St John's day it receives a plentiful mixture of the fresh and fallen rain from Ethiopia, which dilutes and refreshes the almost corrupted river, and the sun near at hand exerts its influence upon the water, which is now become light enough to be exhaled, tho' it has still with it a mixture of the corrupted fluid. It is in February, March, or April only, that the plague begins in Egypt." Our philosophical traveller does not believe it an endemical disease; but assigns very sufficient reasons for thinking that it comes from Constantinople with merchandise or with passengers at the very time of the year when the air, by the long absence of

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Numa.

dews, has attained a degree of putridity proper to receive it. In this state of the atmosphere, the infection continues to rage till the period of St John's day, when it is suddenly stopped by the dews occasioned by a refreshing mixture of rain water, which is poured into the Nile at the beginning of the inundation. The first and most remarkable sign of the change effected in the air, is the sudden stopping of the plague. Every person, though shut up from society for months before, buys, sells, and communicates with his neighbour without any sort of apprehension; and as far as our author could learn upon fair inquiry, it was never known that one fell sick of the plague after the anniversary of St John. He admits that some have died of it after that period; but of them the disease had got such hold, under the most putrid influence of the air, that they could not recover. To corroborate this theory, which attributes so much to the benign influence of the falling dew, he observes, that immediately after St John's day, the clothes of the many thousands who have died during the late continuance of the plague are publicly exposed in the market place; and that all these, though consisting of furs, cotton, silk, and woollen cloths, which are the stuffs most retentive of infection, imbibing the moist air of the evening and the morning, are handled, bought, put on and worn, without any apprehension of danger, and without a single accident being known to have happened to any one possessed of this happy confidence.

NUDITIES, in painting and sculpture, those parts of an human figure which are not covered with any drapery; or those parts where the carnation appears.

NULLITY, in law, signifies any thing that is null or void: thus there is a nullity of marriage, where persons marry within the degrees, or where infants marry without consent of their parents or guardians.

NUMA (Pompilius), the fourth son of Pompilius Pompo, an illustrious Sabine. He had married Tatia, the daughter of king Tattius, and together with her remained in his native country, preferring the tranquillity of a private life to the splendor of a court. Upon the death of his wife, with whom he had lived thirteen years, he gave himself up entirely to the study of wisdom; and, leaving the city of Cures, confined himself to the country, wandering from solitude to solitude, in search only of those woods and fountains which religion had made sacred. His reclusive life gave rise to the fable, which was very early received among the Sabines, that Numa lived in familiarity with the nymph Egeria. Upon the death of Romulus both the senate and people strongly solicited him to be their king. They dispatched Julius Proculus and Valerius Volesus, two senators of distinction, to acquaint Numa with their resolution, and make him an offer of the kingdom. The Sabine philosopher rejected at first their proposal; but being at last prevailed upon by the arguments and intreaties of the deputies, joined with those of his father and of Martius his near relation, he yielded; and having offered sacrifices to the gods, set out for Rome, where he was received by all ranks of people with loud shouts of joy. Spurius Vettius, the interrex for the day, having assembled the curiæ, he was elected in due form, and the election was unanimously confirmed by the senate.

The beginning of his reign was popular; and he

dismissed the 300 body-guards which his predecessor had kept around his person, and observed, that he did not distrust a people who had compelled him to reign over them. He was not, like Romulus, fond of war and military expeditions, but he applied himself to tame the ferocity of his subjects, to inculcate in their minds a reverence for the Deity, and to quell their dissensions by dividing all the citizens into different classes. He established different orders of priests, and taught the Romans not to worship the Deity by images; and from his example no graven or painted statues appeared in the temples or sanctuaries of Rome for the space of 160 years. He encouraged the report that was spread of his paying regular visits to the nymph Egeria, and made use of her name to give sanction to the laws and institutions which he had introduced. He established the college of the vestals, and told the Romans that the safety of the empire depended upon the preservation of the sacred *ancyle* or shield, which, as was generally believed, had dropped from heaven. He dedicated a temple to Janus, which, during his whole reign, remained shut as a mark of peace and tranquillity at Rome. After a reign of 42 years, in which he had given every possible encouragement to the useful arts, and in which he had cultivated peace, Numa died in the year of Rome 82. Not only the Romans, but also the neighbouring nations, were eager to pay their last offices to a monarch whom they revered for his abilities, moderation, and humanity. He forbade his body to be burnt according to the custom of the Romans; but he ordered it to be buried near mount Janiculum, with many of the books which he had written. These books were accidentally found by one of the Romans, about 400 years after his death; and as they contained nothing new or interesting, but merely the reasons why he had made innovations in the form of worship and in the religion of the Romans, they were burnt by order of the senate. He left behind him one daughter called Pompilia, who married Numa Marcius, and became the mother of Ancus Marcius the fourth king of Rome. Some say that he had also four sons; but this opinion is ill-founded. The principal laws of king Numa, mentioned by different authors, are, 1. That the gods should be worshipped with corn and a salted cake. 2. That whoever knowingly killed a free man, should be held as a parricide. 3. That no harlot should touch the altar of Juno; and if she did, that she should sacrifice an ewe-lamb to that goddess, with dishevelled hair. 4. That whoever removed a land-mark should be put to death. 5. That wine should not be poured on a funeral pile, &c.

NUMANTIA, a very noble city, the ornament of the Hither Spain, (Florus); celebrated for the long war of 20 years which it maintained against the Romans. The baseness and injustice of the Romans during this war was truly disgraceful to them, and altogether unworthy of a great and powerful people. The inhabitants obtained some advantages over the Roman forces, till Scipio Africanus was empowered to finish the war and to see the destruction of Numantia. He began the siege with an army of 60,000 men, and was bravely opposed by the besieged, who were no more than 4000 men able to bear arms. Both armies behaved with uncommon valour, and the courage of the Numantines was soon changed into despair and fury.

Their

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Numantia.

Number. Their provisions began to fail, and they fed upon the flesh of their horses, and afterwards on that of their dead companions, and at last they were obliged to draw lots to kill and devour one another. The melancholy situation of their affairs obliged them to surrender to the Roman general. Scipio demanded them to deliver themselves up on the morrow; they refused, and when a longer time had been granted to their petitions, they retired and set fire to their houses and destroyed themselves, so that not even one remained to adorn the triumph of the conqueror. Some historians, however, deny that; and assert, that a number of Numantines delivered themselves into Scipio's hands, and that 50 of them were drawn in triumph at Rome, and the rest sold as slaves. The fall of Numantia was more glorious than that of Carthage or Corinth, though the place was much inferior to them. It was taken by the Romans, A. U. C. 629; and the conqueror obtained the surname of *Numantinus*.

NUMBER, an assemblage of several units, or things of the same kind. See *ARITHMETIC*, and *METAPHYSICS*, n^o 205—208.

Number, says Malcolm, is either abstract or applicate: Abstract, when referred to things in general, without attending to their particular properties; and applicate, when considered as the number of a particular sort of things, as yards, trees, or the like.

When particular things are mentioned, there is always something more considered than barely their numbers; so that what is true of numbers in the abstract, or when nothing but the number of things is considered, will not be true when the question is limited to particular things: for instance, the number two is less than three; yet two yards is a greater quantity than three inches: and the reason is, because regard must be had to their different natures as well as number, whenever things of a different species are considered; for though we can compare the number of such things abstractedly, yet we cannot compare them in any applicate sense. And this difference is necessary to be considered, because upon it the true sense, and the possibility or impossibility, of some questions depend.

Number is unlimited in respect of increase; because we can never conceive a number so great but still there is a greater. However, in respect of decrease, it is limited; unity being the first and least number, below which therefore it cannot descend.

Kinds and distinctions of NUMBERS. Mathematicians, considering number under a great many relations, have established the following distinctions.

Broken numbers are the same with fractions.

Cardinal numbers are those which express the quantity of units, as 1, 2, 3, 4, &c. whereas ordinal numbers are those which express order, as 1st, 2d, 3d, &c.

Compound number, one divisible by some other number besides unity; as 12, which is divisible by 2, 3, 4, and 6. Numbers, as 12 and 15, which have some common measure besides unity, are said to be compound numbers among themselves.

Cubic number is the product of a square number by its root: such is 27, as being the product of the square number 9 by its root 3. All cubic numbers, whose root is less than 6, being divided by 6, the re-

mainder is the root itself; thus $27 \div 6$ leaves the remainder 3, its root; 215, the cube of 6, being divided by 6, leaves no remainder; 343, the cube of 7, leaves a remainder 1, which added to 6, is the cube root; and 512, the cube of 8, divided by 6, leaves a remainder 2, which added to 6, is the cube root. Hence the remainders of the divisions of the cubes above 216, divided by 6, being added to 6, always gives the root of the cube so divided till that remainder be 5, and consequently 11, the cube-root of the number divided. But the cubic numbers above this being divided by 6, there remains nothing, the cube root being 12. Thus the remainders of the higher cubes are to be added to 12 and not to 6, till you come to 18, when the remainder of the division must be added to 18; and so on *ad infinitum*.

Determinate number is that referred to some given unit, as a ternary or three: whereas an indeterminate one is that referred to unity in general, and is called *quantity*.

Homogeneous numbers are those referred to the same unit; as those referred to different units are termed *heterogeneous*.

Whole numbers are otherwise called *integers*.

Rational number is one commensurable with unity; as a number, incommensurable with unity, is termed *irrational*, or a *furd*.

In the same manner, a rational whole number is that whereof unity is an aliquot part; a rational broken number, that equal to some aliquot part of unity; and a rational mixed number, that consisting of a whole number and a broken one.

Even number, that which may be divided into two equal parts without any fraction, as 6, 12, &c. The sum, difference, and product, of any number of even numbers, is always an even number.

An evenly even number, is that which may be measured, or divided, without any remainder, by another even number, as 4 by 2.

An unevenly even number, when a number may be equally divided by an uneven number, as 20 by 5.

Uneven number, that which exceeds an even number, at least by unity, or which cannot be divided into two equal parts, as 3, 5, &c.

The sum or difference of two uneven numbers makes an even number; but the factum of two uneven ones makes an uneven number.

If an even number be added to an uneven one, or if the one be subtracted from the other, in the former case the sum, in the latter the difference, is an uneven number; but the factum of an even and uneven number is even.

The sum of any even number of uneven numbers is an even number; and the sum of any uneven number of uneven numbers is an uneven number.

Primitive or prime numbers are those divisible only by unity, as 5, 7, &c. And prime numbers among themselves, are those which have no common measure besides unity, as 12 and 19.

Perfect number, that whose aliquot parts added together make the whole number, as 6, 28; the aliquot parts of 6 being 3, 2, and $1=6$; and those of 28, being 14, 7, 4, 2, $1=28$.

Imperfect numbers, those whose aliquot parts added together make either more or less than the whole.

And

Number.

And these are distinguished into abundant and defective: an instance in the former case is 12, whose aliquot parts 6, 4, 3, 2, 1, make 16; and in the latter case 16, whose aliquot parts 8, 4, 2, and 1, make but 15.

Plain number, that arising from the multiplication of two numbers, as 6, which is the product of 3 by 2; and these numbers are called the *sides of the plane*.

Square number is the product of any number multiplied by itself; thus 4, which is the factum of 2 by 2, is a square number.

Even square number added to its root makes an even number.

Polygonal or polygonous numbers, the sums of arithmetical progressions beginning with unity: these, where the common difference is 1, are called *triangular numbers*; where 2, *square numbers*; where 3, *pentagonal numbers*; where 4, *hexagonal numbers*; where 5, *heptagonal numbers*, &c.

Pyramidal numbers, the sums of polygonous numbers, collected after the same manner as the polygons themselves, and not gathered out of arithmetical progressions, are called *first pyramidal numbers*; the sums of the first pyramidal are called *second pyramidal*, &c.

If they arise out of triangular numbers, they are called *triangular pyramidal numbers*; if out of pentagons, *first pentagonal pyramidal*.

From the manner of summing up polygonal numbers, it is easy to conceive how the prime pyramidal numbers are found, viz. $\frac{(a-2)n^3 + 3n^2 - (a-5)n}{6}$ expresses all the prime pyramidal.

The number nine has a very curious property, its products always composing either 9 or some lesser product of it. We have already given an account of this, with the examples from Hume, under the article NINE; and we need not repeat them. Did our limits permit us, we could instance in a variety of other properties numbers both curious and surprising. Such speculations are indeed by some men considered as trifling and useless: but perhaps they judge too hastily; for few employments are more innocent, none more ingenious, nor, to those who have a taste for them, more amusing.

Numbers were by the Jews, as well as the ancient Greeks and Romans, expressed by letters of the alphabet: hence we may conceive how imperfect and limited their arithmetic was, because the letters could not be arranged in a series, or in different lines conveniently enough for the purposes of ready calculation. The invention of the cypher, or arithmetical figures, which we now make use of, has given us a very great advantage over the ancients in this respect.

Mankind, we may reasonably suppose, first reckoned by their fingers, which they might indeed do in a variety of ways. From this digital arithmetic, very probably, is owing the number 10, which constitutes the whole set of arithmetical figures.

The letters chiefly employed by the Romans to express numbers were, M, for 1000; D, for 500; C, for 100; L, for 50; V, for 5; X, for 10; and I, for 1.—M, probably signified 1000, because it is the initial of *mille*; D stands for 500, because it is *dimidium mille*; C signifies 100, as being the first letter

Number.

of the word *centum*; L stands for 50, because it is the half of C, having formerly been wrote thus C; V signifies 5, because V is the fifth vowel; X stands for 10, because it contains twice V or V in a double form;

I stands for one, because it is the first letter of *initium*. These however are fanciful derivations. See NUMERAL Letters.

The Jewish cabbalists, the Grecian conjurors, and the Roman augurs, had a great veneration for particular numbers, and the result of particular combinations of them. Thus three, four, six, seven, nine, ten, are full of divine mysteries, and of great efficacy.

Golden NUMBER. See CHRONOLOGY, n° 27.

NUMBERS, in poetry, oratory, &c. are certain measures, proportions, or cadences, which render a verse, period, or song, agreeable to the ear.

Poetical numbers consist in a certain harmony in the order, quantities, &c. of the feet and syllables, which make the piece musical to the ear, and fit for singing, for which all the verses of the ancients were intended. See POETRY.—It is of these numbers Virgil speaks in his ninth Eclogue, when he makes Lycidas say, *Numeros memini, si verba tenerem*; meaning, that although he had forgot the words of the verses, yet he remembered the feet and measure of which they were composed.

Rhetorical or prosaic numbers are a sort of simple unaffected harmony, less glaring than that of verse, but such as is perceived and affects the mind with pleasure.

The numbers are that by which the style is said to be easy, free, round, flowing, &c. Numbers are things absolutely necessary in all writing, and even in all speech. Hence Aristotle, Tully, Quintilian, &c. lay down abundance of rules as to the best manner of intermixing dactyles, spondees, anapests, &c. in order to have the numbers perfect. The substance of what they have said, is reducible to what follows. 1. The style becomes numerous by the alternate disposition and temperature of long and short syllables, so as that the multitude of short ones neither render it too hasty, nor that of long ones too slow and languid: sometimes, indeed, long and short syllables are thrown together designedly without any such mixture, to paint the slowness or celerity of any thing by that of the numbers; as in these verses of Virgil:

Illi inter sese magna vi brachia tollunt;

and

Radit iter liquidum, celeres neque commovet alas.

2. The style becomes numerous, by the intermixing words of one, two, or more syllables; whereas the too frequent repetition of monosyllables renders the style pitiful and grating. 3. It contributes greatly to the numerousness of a period, to have it closed by magnificent and well-sounding words. 4. The numbers depend not only on the nobleness of the words in the close, but of those in the whole tenor of the period. 5. To have the period flow easily and equally, the harsh concurrence of letters and words is to be studiously avoided, particularly the frequent meeting of rough consonants; the beginning the first syllable of a word with the last of the preceding; the frequent repetition of the same letter or syllable; and the frequent use of the like ending words. Lastly, the utmost

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most care is to be taken lest, in aiming at oratorical numbers, you should fall into poetical ones; and instead of prose, write verse.

Book of NUMBERS, the fourth book of the Pentateuch, taking its denomination from its numbering the families of Israel.

A great part of this book is historical, relating to several remarkable passages in the Israelites march through the wilderness. It contains a distinct relation of their several movements from one place to another, or their 42 stages through the wilderness, and many other things, whereby we are instructed and confirmed in some of the weightiest truths that have immediate reference to God and his providence in the world. But the greatest part of this book is spent in enumerating those laws and ordinances, whether civil or ceremonial, which were given by God, but not mentioned before in the preceding books.

NUMERAL LETTERS, those letters of the alphabet which are generally used for figures; as I, one; V, five; X, ten; L, fifty; C, a hundred; D, five hundred; M, a thousand, &c.

It is not agreed how the Roman numerals originally received their value. It has been supposed, as we have observed in the end of the article NUMBER, that the Romans used M to denote 1000, because it is the first letter of *mille*, which is Latin for 1000; and C to denote 100, because it is the first letter of *centum*, which is Latin for 100. It has also been supposed, that D, being formed by dividing the old M in the middle, was therefore appointed to stand for 500, that is, half as much as the M stood for when it was whole; and that L being half a C, was, for the same reason, used to denominate 50. But what reason is there to suppose, that 1000 and 100 were the numbers which letters were first used to express? And what reason can be assigned why D, the first letter in the Latin word *decem*, ten, should not rather have been chosen to stand for that number, than for 500, because it had a rude resemblance to half an M? But if these questions could be satisfactorily answered, there are other numeral letters which have never yet been accounted for at all. These considerations render it probable that the Romans did not, in their original intention, use letters to express numbers at all; the most natural account of the matter seems to be this:

The Romans probably put down a single stroke, I, for one, as is still the practice of those who score on a slate or with chalk: this stroke, I, they doubled, trebled, and quadrupled, to express 2, 3, and 4: thus, II. III. IIII. So far they could easily number the strokes with a glance of the eye. But they presently found, that if more were added, it would soon be necessary to tell the strokes one by one: for this reason, when they came to 5, they expressed it by joining two strokes together in an acute angle thus, V; which will appear the more probable, if it be considered that the progression of the Roman numbers is from 5 to 5, i. e. from the fingers on one hand to the fingers on the other.—Ovid has touched upon the original of this in his *Fastorum*, lib. iii. and *Vitruv.* lib. c. 1. has made the same remark.

After they had made this acute angle V. for five, they added the single strokes to it to the number of 4, thus, VI. VII. VIII. IIII. and then as the

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strokes could not be further multiplied without confusion, they doubled their acute angle, by prolonging the two lines beyond their intersection thus, X. to denote two fives, or ten. After this they doubled, trebled, and quadrupled, this double acute angle thus, XX. XXX. XXXX. they then, for the same reason which induced them first to make a single and then to double it, joined two single strokes in another form, and instead of an acute angle, made a right angle L, to denote fifty. When this 50 was doubled, they then doubled the right angle thus C, to denote 100, and having numbered this double right angle four times, thus CC CCC EEEE; when they came to the fifth number, as before, they reverted it, and put a single stroke before it thus, I C, to denote 500; and when this 500 was doubled, then they also doubled their double right angle, setting two double right angles opposite to each other, with a single stroke between them, thus C I C to denote 1000: when this note for 1000 had been four times repeated, then they put down I C C C for 5,000, CC I C C for 10,000, and I C C C C for 50,000 CCC I C C C C for 100,000, I C C C C C for 500,000, and C C C C C I C C C C for one million.

That the Romans did not originally write M for 1000, and C for 100, but square characters, as they are written above, we are expressly informed by Paulus Manutius; but the corners of the angles being cut off by the transcribers for dispatch, these figures were gradually brought into what are now numeral letters. When the corners of C I C were made round, it stood thus C I O, which is so near the Gothic *m*, that it soon deviated into that letter; so I C having the corner made round, it stood thus I O, and then easily deviated into D. C also became a plain C by the same means; the single rectangle which denoted 50, was, without alteration, a capital L; the double acute angle was an X; the single acute angle a V consonant; and a plain single stroke, the letter I; and thus these seven letters, M, D, C, L, X, V, I, became numerals.

NUMERAL Characters of the Arabs, are those figures which are now used in all the operations of arithmetic in every nation of Europe. We have elsewhere shown that the Arabs derived the use of them most probably from India, (See ARITHMETIC, N^o 5.) This opinion, however, though very generally received, has been controverted with some ingenuity. A writer in the Gentleman's Magazine, at a period when that miscellany was in its highest reputation, thus endeavours to prove that the Arabs derived their notations from the Greeks. "I maintain (says he) that the Indians received their numeral characters from the Arabians, and the Arabians from the Greeks, as from them they derived all their learning, which in some things they improved, but for the most part have altered. The numerical figures which they received from the Greeks are proofs of this alteration; which is so great, that without particular attention one can scarce discover in them the vestiges of their origin. But when we compare them carefully, and without prejudice, we find in them manifest traces of the Greek figures. The Greek numerical figures were no other than the letters of their alphabet. A small stroke was the mark of unity. The B, being abridged of its two extremities, produced the 2. If you incline the γ a little on its left side, and cut off its foot, and make the left horn round towards the left side, you will produce a 3; the Δ makes the 4, by raising

Numeral raising the right leg perpendicularly, and lengthening it a little below the base, and lengthening the base on the left side. The forms the 5, by turning the lowest semicircle towards the right, which before was turned towards the left side. The number 5 forms the 6 by having its head taken off, and its body rounded. Z, by taking away the base, makes the 7. If we make the top and bottom of H round, we shall form an 8. The 9 is the 9 with very little alteration. The cypher 0 was only a point, to which one of the figures was added to make it stand for ten times as much. It was necessary to mark this point very strongly; and in order to form it better, a circle was made, which was filled up in the middle; but that circumstance was afterwards neglected. Theophrastus, an historian of Constantinople, who lived in the ninth century, says expressly, that the Arabians retained the Greek figures, having no characters in their language to represent all the numbers. The Greeks observed in their numbers the decuple progression, which the Arabians have retained. Certain characters are found in the Greek alphabet, which are not used in reading, but only in calculation, and for this reason they are styled *Epifemes*, that is to say, *notes, marks*, in order to distinguish them from letters. The number 6 derives its form from one of these epifemes, which was called *ἑξήκοντα*. This epifeme forms the letter F among the *Æolians* and among the *Latins*. This was called the *Digamma*, so styled from its figure, which seems to have been one placed upon another.

That this reasoning is plausible will hardly be questioned; but whether it be conclusive our readers must determine. It has not convinced ourselves; but through the whole of this work we wish to state candidly the different opinions held on every subject of curiosity and usefulness.

NUMERATION, or **NOTATION**, in arithmetic, the art of expressing in characters any number proposed in words, or of expressing in words, any number proposed in characters. See **ARITHMETIC**, n° 7.

NUMERICAL, **NUMEROUS**, or *Numeral*, something belonging to numbers; as numerical algebra is that which makes use of numbers, instead of letters of the alphabet.—Also numerical difference is that by which one man is distinguished from another. Hence a thing is said to be numerically the same, when it is so in the strictest sense of the word.

NUMIDA, in ornithology, a genus belonging to the order of gallinæ. On each side of the head there is a kind of coloured fleshy horn; and the beak is furnished with cere near the nostrils. The species called *meleagris*, or *Guinea hen*, is a native of Africa. It is larger than a common hen. Its body is sloped like that of a partridge, and its colour is all over a dark grey, very beautifully spotted with small white specks; there is a black ring round the neck; its head is reddish, and it is blue under the eyes. They naturally herd together in large numbers, and breed up their young in common; the females taking care of the broods of others, as well as of their own. Barbut informs us, that in Guinea they go in flocks of 200 or 300, perch on trees, and feed on worms and grasshoppers; that they are run down and taken by dogs; and that their flesh is tender and sweet, generally white, though sometimes black. They breed

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very well with us. Mr Latham observes, "that the native place of this bird is, without doubt, Africa, and that it is the *meleagris* of old authors. It is supposed originally to have come from Nubia, and was esteemed in the Roman banquets. It has been met with wild in flocks of two or three hundred by various travellers. Dampier found them in numbers in the island of Mayo; and Forster speaks of them as numerous at St Jago; but they have been transported into the West Indies and America, and are now in a wild state in those places, as well as domesticated."

The white-breasted one is a mere variety, of which there are many: it is mostly found in Jamaica. The mitted, or *numida mitrata*, is a different and not a common species: it inhabits Madagascar and Guinea. Pallas seems to think that it may be the bird mentioned by Columella, as differing from the common one; and will account for Pliny's having thought the *numida* and *meleagris* to be different birds. The third species which Mr Latham mentions is the crested, or *numida cristata*. This species likewise inhabits Africa. Perhaps it may have some relation to the crested fort which Marcgrave mentions to have seen, and which came from Sierra Leon. This had a kind of membranous collar about the neck, was of a bluish ash-colour, and had a large roundish black crest. Buffon, who describes it at great length, calls it *la peintade*. Linnæus and Gmel. call it *Numida meleagris*, &c. Ray and Will. call it *gallus* and *gallina Guineensis*, &c. Mr Pennant contends, and seems to prove, that the *pintados* had been early introduced into Britain, at least prior to the year 1277. But they seem to have been much neglected on account of the difficulty of rearing them; for they occur not in our ancient bills of fare. They have a double caruncle at the chaps, and no fold at the throat.

NUMIDIA, an ancient kingdom of Africa, bounded on the north by the Mediterranean Sea; on the south by *Gætulia*, or part of Libya Interior; on the west by the *Mulucha*, a river which separated it from Mauritania; and on the east by the *Tusca*, another river which bounded it in common with Africa Propria. Dr Shaw has rendered it probable, that the river which formerly went under the denominations of *Malva*, *Malwana*, *Mulucha*, and *Molochath*, is the same with that now called *MULLOOIAN* by the Algerines; in which case, the kingdom of Numidia must have extended upwards of 500 miles in length: its breadth, however, cannot be so well ascertained; but supposing it to have been the same with that of the present kingdom of Algiers, in the narrowest part it must have been at least 40 miles broad, and in the widest upwards of 100.

This country included two districts; one inhabited by the *Massyli*, and the other by the *Massyli*; the latter being also called in after times *Mauritania Cæsariensis*, and the former *Numidia Propria*. The country of the *Massyli*, or, as some call it, *Terra Metagonitis*, was separated from the proper territory of Carthage by its eastern boundary the river *Tusca*, and from the kingdom of the *Massyli*, or *Mauritania Cæsariensis*, by the river *Amphaga*. It seems to correspond with that part of the province of Constantina lying between the *Zaine* and the *Wed al Kibeer*, which is above 130 miles long, and more than 100 broad. The sea-coast

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Numidia. of this province is for the most part mountainous and rocky, answering to the appellation given to it by Abulfeda, viz. *El Edwaa, the high or lofty*. It is far from being equal in extent to the ancient country of the Masæyli, which, Strabo informs us, was yet inferior to the country of the Massyli. Its capital was Cirta, a place of very considerable note among the ancients.

² **Peopled by the descendants of Phut.** The most celebrated antiquarians agree, that the tract, extending from the isthmus of Suez to the lake Tritonis, was chiefly peopled by the descendants of Mizraim, and that the posterity of his brother Put, or Phut, spread themselves all over the country between that lake and the Atlantic ocean. To this notion Herodotus gives great countenance: for he tells us, that the Libyan Nomades, whose territories to the west were bounded by the Triton, agreed in their customs and manners with the Egyptians; but that the African, from that river to the Atlantic ocean, differed in almost all points from them. Ptolemy mentions a city called *Putea* near Adrametum; and Pliny, a river of Mauritania Tingitana, known by the name of *Put*, or *Phut*; and the district adjacent to this river was called *Regio Phutensis*, which plainly alludes to the name of *Phut*. That word signifies *scattered*, or *dispersed*, which very well agrees with what Mela and Strabo relate of the ancient Numidians; so that we may, without any scruple, admit the aborigines of this country to have been the descendants of Phut.

³ **Great part of the history unknown.** The history of Numidia, during many of the early ages, is buried in oblivion. It is probable, however, that as the Phœnicians were masters of a great part of the country, these transactions had been recorded, and generally known to the Carthaginians. King Jarbas probably reigned here as well as in Africa Propria, if not in Mauritania, and other parts of Lybia, when Dido began to build Byrsa. It appears from Justin, that about the age of Herodotus, the people of this country were called both *Africans* or *Libyans* and *Numidians*. Justin likewise intimates, that about this time the Carthaginians vanquished both the Moors or Mauritians and Numidians; in consequence of which they were excused from paying the tribute which had hitherto been demanded of them.

After the conclusion of the first Punic war, the African troops carried on a bloody contest against their masters the Carthaginians; and the most active in this rebellion, according to Diodorus Siculus, were a part of the Numidian nation named *Micatanians*. This so incensed the Carthaginians, that after Hamilcar had either killed or taken prisoners all the mercenaries, he sent a large detachment to ravage the country of those Numidians. The commandant of that detachment executed his orders with the utmost cruelty, plundering the district in a terrible manner, and crucifying all the prisoners without distinction that fell into his hands. This filled the rest with such indignation and resentment, that both they and their posterity ever afterwards bore an implacable hatred to the Carthaginians.

⁴ **History of Syphax and Masinissa.** In the time of the second Punic war, Syphax king of the Masæyli entered into an alliance with the Romans, and gave the Carthaginians a considerable defeat. This induced Gala, king of the Massyli, to

conclude a treaty with the Carthaginians, in consequence of which his son Masinissa marched at the head of a powerful army to give Syphax battle. The contest ended in favour of Masinissa; 30,000 of the Masæyli were put to the sword, and Syphax driven into Mauritania; and the like bad success attended Syphax in another engagement, where his troops were entirely defeated and dispersed.

Gala dying whilst his son Masinissa was acting at the head of the Numidian troops sent to the assistance of the Carthaginians in Spain, his brother Desalces, according to the established rules of succession in Numidia, took possession of the Massylian throne. That prince dying soon after his accession, Capusa his eldest son succeeded him. But he did not long enjoy his high dignity; for one Mezetulus, a person of the royal blood, but an enemy to the family of Gala, found means to excite a great part of his subjects to revolt. A battle soon took place between him and Capusa; in which the latter was slain with many of the nobility, and his army entirely defeated. But though Mezetulus thus became possessed of the sovereignty, he did not think proper to assume the title of *king*, but styled himself guardian to Lacumaces, the surviving son of Desalces, whom he graced with the royal title. To support himself in his usurpation, he married the dowager of Desalces, who was Hannibal's niece, and consequently of the most powerful family in Carthage. In order to attain the same end, he sent ambassadors to Syphax, to conclude a treaty of alliance with him. In the mean time Masinissa, receiving advice of his uncle's death, of his cousin's slaughter, and of Mezetulus's usurpation, immediately passed over to Africa, and went to the court of Bocchar king of Mauritania, to solicit succours. Bocchar, sensible of the great injustice done Masinissa, gave him a body of 4000 Moors to escort him to his dominions. His subjects, having been apprised of his approach, joined him upon the frontiers with a party of 500 men. The Moors, in pursuance of their orders, returned home, as soon as Masinissa reached the confines of his kingdom. Notwithstanding which, and the small body that declared for him having accidentally met Lacumaces at Thapsus with an escort going to implore Syphax's assistance, he drove him into the town, which he carried by assault, after a faint resistance. However, Lacumaces, with many of his men, found means to escape to Syphax. The fame of this exploit gained Masinissa great credit, insomuch that the Numidians flocked to him from all parts, and, amongst the rest, many of his father Gala's veterans, who pressed him to make a speedy and vigorous push for his hereditary dominions. Lacumaces having joined Mezetulus with a reinforcement of Masæylians, which he had prevailed upon Syphax to send to the assistance of his ally, the usurper advanced at the head of a numerous army to offer Masinissa battle; which that prince, though much inferior in numbers, did not decline. Hereupon an engagement ensued; which, notwithstanding the inequality of numbers, ended in the defeat of Lacumaces. The immediate consequence of this victory of Masinissa was a quiet and peaceable possession of his kingdom; Mezetulus and Lacumaces, with a few that attended them, flying into the territories of Carthage. However, being apprehensive that

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he should be obliged to sustain a war against Syphax, he offered to treat Lacumaces with as many marks of distinction as his father Gala had Desalces, provided that prince would put himself under his protection. He also promised Mezetulus pardon, and a restitution of all the effects forfeited by his treasonable conduct, if he would make his submission to him. Both of them readily complied with the proposal, and immediately returned home; so that the tranquillity and repose of Numidia would have been settled upon a solid and lasting foundation, had not this been prevented by Asdrubal, who was then at Syphax's court. He insinuated to that prince, who was disposed to live amicably with his neighbours, "That he was greatly mistaken, if he imagined Masinissa would be satisfied with his hereditary dominions. That he was a prince of much greater capacity and ambition, than either his father Gala, his uncle Desalces, or any of his family. That he had discovered in Spain marks of a most rare and uncommon merit. And that, in fine, unless his rising flame was extinguished before it came to too great a head, both the Massæsylian and Carthaginian states would be infallibly consumed by it." Syphax, alarmed by these suggestions, advanced with a numerous body of forces into a district, which had long been in dispute between him and Gala, but was then in possession of Masinissa. This brought on a general action between these two princes; wherein the latter was totally defeated, his army dispersed, and he himself obliged to fly to the top of mount Balbus, attended only by a few of his horse. Such a decisive battle at the present juncture, before Masinissa was fixed in his throne, could not but put Syphax into possession of the kingdom of the Massyli. Masinissa in the mean time made nocturnal incursions from his post upon mount Balbus, and plundered all the adjacent country, particularly that part of the Carthaginian territory contiguous to Numidia. This district he not only thoroughly pillaged, but likewise laid waste with fire and sword, carrying off from thence an immense booty, which was brought by some merchants, who had put into one of the Carthaginian ports for that purpose. In fine, he did the Carthaginians more damage, not only by committing such dreadful devastations, but by massacring and carrying into captivity vast numbers of their subjects on this occasion, than they could have sustained in a pitched battle, or one campaign of a regular war. Syphax, at the pressing and reiterated instances of the Carthaginians, sent Bocchar, one of his most active commanders, with a detachment of 4000 foot, and 2000 horse, to reduce this pestilent gang of robbers, promising him a great reward if he could bring Masinissa either alive or dead. Bocchar, watching an opportunity, surprised the Massylians, as they were straggling about the country without any order or discipline; so that he took many prisoners, dispersed the rest, and pursued Masinissa himself, with a few of his men, to the top of the mountain where he had before taken post. Considering the expedition as ended, he not only sent many head of cattle, and the other booty that had fallen into his hands, to Syphax, but likewise all the force, except 500 foot and 200 horse. With this detachment he drove Masinissa from the summit of the hill, and pursued him through several

narrow passes and defiles, as far as the plains of Clupea. Here he so surrounded him, that all the Massylians, except four, were put to the sword, and Masinissa himself, after having received a dangerous wound, escaped with the utmost difficulty. As this was effected by crossing a rapid river, in which attempt two of his four attendants perished in the sight of the detachment that pursued him, it was rumoured all over Africa, that Masinissa also was drowned; which gave inexpressible pleasure to Syphax and the Carthaginians. For some time he lived undiscovered in a cave, where he was supported by the robberies of the two horsemen that had made their escape with him. But having cured his wound by the application of some medicinal herbs, he boldly began to advance towards his own frontiers, giving out publicly that he intended once more to take possession of his kingdom. In his march he was joined by about 40 horse, and, soon after his arrival amongst the Massyli, so many people flocked to him from all parts, that out of them he formed an army of 6000 foot and 4000 horse. With these forces, he not only reinstated himself in the possession of his dominions, but likewise laid waste the borders of the Massæsyli. This so irritated Syphax, that he immediately assembled a body of troops, and encamped very commodiously upon a ridge of mountains between Cirta and Hippo. His army he commanded in person; and detached his son Vermina, with a considerable force, to take a compass, and attack the enemy in the rear. In pursuance of his orders, Vermina set out in the beginning of the night, and took post in the place appointed him, without being discovered by the enemy. In the mean time Syphax decamped, and advanced towards the Massyli, in order to give them battle. When he had possessed himself of a rising ground that led to their camp, and concluded that his son Vermina must have formed the ambuscade behind them, he began the fight. Masinissa being advantageously posted, and his soldiers distinguishing themselves in an extraordinary manner, the dispute was long and bloody. But Vermina unexpectedly falling upon their rear, and by this means obliging them to divide their forces, which were scarce able before to oppose the main body under Syphax, they were soon thrown into confusion, and forced to betake themselves to a precipitate flight. All the avenues being blocked up, partly by Syphax and partly by his son, such a dreadful slaughter was made of the unhappy Massyli, that only Masinissa himself, with 60 horse, escaped to the Lesser Syrtis. Here he remained, betwixt the confines of the Carthaginians and Garamantes, till the arrival of Lælius and the Roman fleet on the coast of Africa. What happened immediately after this junction with the Romans, belongs to the article ROME.

It will be sufficient therefore in this place to observe, that, by the assistance of Lælius, Masinissa at last reduced Syphax's kingdom. According to Zonaras, Masinissa and Scipio, before the memorable battle of Zama, by a stratagem deprived Hannibal of some advantageous posts; which, with a solar eclipse happening during the heat of the action, and not a little intimidating the Carthaginian troops, greatly contributed to the victory the Romans obtained. At the conclusion therefore of the second Punic war, he was amply rewarded.

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Numidia. warded by the Romans for the important services he had done them. As for Syphax, after the loss of his dominions, he was kept in confinement for some time at Alba; from whence being removed in order to grace Scipio's triumph, he died at Tibur in his way to Rome. Zonaras adds, that his corpse was decently interred; that all the Numidian prisoners were released; and that Vermina, by the assistance of the Romans, took peaceable possession of his father's throne. However, part of the Massæsylian kingdom had been before annexed to Masinissa's dominions, in order to reward that prince for his singular fidelity and close attachment to the Romans.

This seems to be countenanced by the epitomizer of Livy, who gives us sufficiently to understand, that Syphax's family, for a considerable time after the conclusion of the second Punic war, reigned in one part of Numidia. For he intimates, that Archobarzanes, Syphax's grandson, and probably Vermina's son, hovered with a powerful army of Numidians upon the Carthaginian frontiers a few years before the beginning of the third Punic war. This he seems to have done, either in order to cover them, or to enable the Carthaginians to make an irruption into Masinissa's territories. Cato, however, pretended that these forces, in conjunction with those of Carthage, had a design to invade the Roman dominions, which he urged as a reason to induce the conscript fathers to destroy the African republic.

Nothing is further requisite, in order to complete the history of this famous prince, than to exhibit to our readers view some points of his conduct towards the decline, and at the close, of life; the wise dispositions made after his death by Æmilianus, in order to the regulation of his domestic affairs; and some particulars relating to his character, genius, and habit of body, drawn from the most celebrated Greek and Roman authors.

By drawing a line of circumvallation around the Carthaginian army under Asdrubal, posted upon an eminence, Masinissa cut off all manner of supplies from them; which introduced both the plague and famine into their camp. As the body of Numidian troops employed in this blockade was not near so numerous as the Carthaginian forces, it is evident, that the line here mentioned must have been extremely strong, and consequently the effect of great labour and art. The Carthaginians, finding themselves reduced to the last extremity, concluded a piece upon the following terms, which Masinissa dictated to them: 1. That they should deliver up all deserters. 2. That they should recal their exiles, who had taken refuge in his dominions. 3. That they should pay him 5000 talents of silver within the space of 50 years. 4. That their soldiers should pass under the jugum, each of them carrying off only a single garment. As Masinissa himself, though between 80 and 90 years of age, conducted the whole enterprise, he must have been extremely well versed in fortification, and other branches of the military art. His understanding likewise he must have retained to the last. This happened a short time before the beginning of the third Punic war. See CARTHAGE.

Soon after, the consuls landed an army in Africa, in order to lay siege to Carthage, without imparting to

Masinissa their design. This not a little chagrined him, as it was contrary to the former practice of the Romans; who in the preceding war had communicated their intentions to him, and consulted him on all occasions. When, therefore, the consuls applied to him for a body of his troops to act in concert with their forces, he made answer, "That they should have a reinforcement from him when they stood in need of it." It could not but be provoking to him to consider, that after he had extremely weakened the Carthaginians, and even brought them to the brink of ruin, his pretended imperious friends should come to reap the fruits of his victory, without giving him the least intelligence of it.

However, his mind soon returned to its natural bias, which was in favour of the Romans. Finding his end approaching, he sent to Æmilianus, then a tribune in the Roman army, to desire a visit from him. What he proposed by this visit, was to invest him with full powers to dispose of his kingdom and estate as he should think proper, for the benefit of his children. The high idea he had entertained of that young hero's abilities and integrity, together with his gratitude and affection for the family into which he was adopted, induced him to take this step. But, believing that death would not permit him to have a personal conference with Æmilianus upon this subject, he informed his wife and children in his last moments, that he had empowered him to dispose in an absolute manner of all his possessions, and to divide his kingdom amongst his sons. To which he subjoined, "I require, that whatever Æmilianus may decree, shall be executed as punctually as if I myself had appointed it by my will." Having uttered these words, he expired, at about 90 years of age.

This prince, during his youth, had met with strange reverses of fortune. However, says Appian, being supported by the Divine protection, he enjoyed an uninterrupted course of prosperity for a long series of years. His kingdom extended from Mauritania to the western confines of Cyrenaica; from whence it appears, that he was one of the most powerful princes of Africa. Many of the inhabitants of this vast tract he civilized in a wonderful manner, teaching them to cultivate their soil, and to reap those natural advantages which the fertility of some parts of their country offered them. He was of a more robust habit of body than any of his contemporaries, being blessed with the greatest health and vigour; which was doubtless owing to his extreme temperance, and the toils he incessantly sustained. We are informed by Polybius, that sometimes he stood upon the same spot of ground from morning till evening, without the least motion, and at others continued as long in a sitting posture. He would remain on horseback for several days and nights together, without being sensible of the least fatigue. Nothing can better evince the strength of his constitution, than his youngest son, named *Stemba*, *Sthemba*, or *Stembanus*, who was but four years old at his decease. Though 90 years of age, he performed all the exercises used by young men, and always rode without a saddle. Pliny tells us, that he reigned above 60 years. He was an able commander, and much facilitated the reduction of Carthage. Plutarch from Polybius observes, that the day after a great victory won

Numidia.

⁵ Masinissa
displeased
with the
Romans.

⁶ But leaves
every thing
to the dis-
posal of Æ-
milianus.

Numidia. over the Carthaginians, Masinissa was seen sitting at the door of his tent, eating a piece of brown bread. Suidas relates, that to the last he could mount his horse without any assistance. According to Appian, he left a numerous well disciplined army, and an immense quantity of wealth, behind him.

Masinissa, before his death, gave his ring to his eldest son Micipsa; but left the distribution of all his other effects and possessions amongst his children entirely to Æmilianus. Of 54 sons that survived him, only three were legitimate, to wit, Micipsa, Gulussa, and Mastanabal. Æmilianus, arriving at Cirta after he had expired, divided his kingdom, or rather the government of it, amongst these three, though to the others he gave considerable possessions. To Micipsa, who was a prince of a pacific disposition, and the eldest son, he assigned Cirta, the metropolis, for the place of his residence, in exclusion of the others. Gulussa, the next to him, being a prince of a military genius, had the command of the army, and the transacting of all affairs relating to peace or war committed to his care. And Mastanabal, the youngest, had the administration of justice, an employment suitable to his education, allotted him. They enjoyed in common the immense treasures Masinissa had amassed, and were all of them dignified by Æmilianus with the royal title. After he had made these wise dispositions, that young nobleman departed from Cirta, taking with him a body of Numidian troops, under the conduct of Gulussa, to reinforce the Roman army that was then acting against the Carthaginians.

Mastanabal and Gulussa died soon after their father, as appears from the express testimony of Sallust. We find nothing more remarkable of these princes, besides what has been already related, than that the latter continued to assist the Romans in the third Punic war, and that the former was pretty well versed in the Greek language. Micipsa therefore became sole possessor of the kingdom of Numidia. In his reign, and under the consulate of M. Plautius Hypsæus and M. Fulvius Flaccus, according to Orosius, a great part of Africa was covered with locusts, which destroyed all the produce of the earth, and even devoured dry wood. But at last they were all carried by the wind into the African sea, out of which being thrown in vast heaps upon the shore, a plague ensued, which swept away an infinite number of animals of all kinds. In Numidia only 800,000 men perished, and in Africa Propria 200,000; amongst the rest, 30,000 Roman soldiers quartered in and about Utica for the defence of the last province. At Utica, in particular, the mortality raged to such a degree, that 1500 dead bodies were carried out of one gate in a day. Micipsa had two sons, Adherbal and Hiempsal, whom he educated in his palace, together with his nephew Jugurtha. That young prince was the son of Mastanabal; but his mother having been only a concubine, Masinissa had taken no great notice of him. However, Micipsa considering him as a prince of the blood, took as much care of him as he did of his own children.

⁷ **History of Jugurtha.** Jugurtha possessed several eminent qualities, which gained him universal esteem. He was very handsome, endued with great strength of body, and adorned with the finest intellectual endowments. He did not devote himself, as young men commonly do, to a life of lux-

ury and pleasure. He used to exercise himself, with **Numidia.** persons of his age, in running, riding, hurling the javelin, and other manly exercises, suited to the martial genius of the Numidians; and though he surpassed all his fellow sportsmen, there was not one of them but loved him. The chase was his only delight; but it was that of lions and other savage beasts. Sallust, to finish his character, tells us, that he excelled in all things, and spoke very little of himself.

So conspicuous an assemblage of fine talents and perfections, at first charmed Micipsa, who thought them an ornament to his kingdom. However, he soon began to reflect, that he was considerably advanced in years, and his children in their infancy; that mankind naturally thirsted after power, and that nothing was capable of making men run greater lengths than a vicious and unlimited ambition. These reflections soon excited his jealousy, and determined him to expose Jugurtha to a variety of dangers, some of which, he entertained hopes, might prove fatal to him. In order to this, he gave him the command of a body of forces which he sent to assist the Romans, who were at that time besieging Numantia in Spain. But Jugurtha, by his admirable conduct, not only escaped all those dangers, but likewise won the esteem of the whole army, and the friendship of Scipio, who sent a high character of him to his uncle Micipsa. However, that general gave him some prudent advice in relation to his future conduct; observing, no doubt, in him certain sparks of ambition, which, if lighted into a flame, he apprehended might one day be productive of the most fatal consequences.

Before this last expedition, Micipsa had endeavoured to find out some method of taking him off private-ly; but his popularity amongst the Numidians obliged that prince to lay aside all thoughts of this nature. After his return from Spain the whole nation almost adored him. The heroic bravery he had shown there, his undaunted courage, joined to the utmost calmness of mind, which enabled him to preserve a just medium between a timorous foresight and an impetuous rashness, a circumstance rarely to be met with in persons of his age, and above all the advantageous testimonials of his conduct given by Scipio, attracted an universal esteem. Nay, Micipsa himself, charmed with the high idea the Roman general had entertained of his merit, changed his behaviour towards him; resolving, if possible, to win his affection by kindness. He therefore adopted him, and declared him joint heir with his two sons to the crown. Finding, some few years afterwards, that his end approached, he sent for all three to his bed-side; where, in the presence of the whole court, he desired Jugurtha to recollect with what extreme tenderness he had treated him, and consequently to consider how well he had deserved at his hands. He then intreated him to protect his children on all occasions; who, being before related to him by the ties of blood, were now by their father's bounty become his brethren. In order to fix him the more firmly in their interest, he likewise complimented him upon his bravery, address, and consummate prudence. He further insinuated, that neither arms nor treasures constitute the strength of a kingdom; but friends, who are neither won by arms nor gold, but by real services, and an inviolable fidelity. "Now where (continued

⁸ is dreaded by king Masinissa.

⁹ Who nevertheless entrusted him with the care of his children.

Numidia. he) can we find better friends than in brothers? And how can that man who becomes an enemy to his relations, repose any confidence in, or depend upon strangers?" Then addressing himself to Adherbal and Hiempsal, "And you (said he) I enjoin always to pay the highest reverence to Jugurtha. Endeavour to imitate, and if possible surpass, his exalted merit, that the world may not hereafter observe Micipsa's adopted son to have reflected greater glory upon his memory than his own children." Soon after, Micipsa, who, according to Diodorus, was a prince of an amiable character, expired. Though Jugurtha did not believe the king to speak his real sentiments with regard to him, yet he seemed extremely pleased with so gracious a speech, and made him an answer suitable to the occasion. However, that prince at the same time was determined within himself to put in execution the scheme he had formed at the siege of Numantia, which was suggested to him by some factious and abandoned Roman officers, with whom he there contracted an acquaintance. The purport of this scheme was, that he should extort the crown by force from his two cousins, as soon as their father's eyes were closed; which they insinuated might easily be effected by his own valour, and the venality of the Romans. Accordingly, a short time after the old king's death, he found means to assassinate Hiempsal in the city of Thirmida where his treasures were deposited, and drive Adherbal out of his dominions. That unhappy prince found himself obliged to fly to Rome, where he endeavoured to engage the conscript fathers to espouse his quarrel; but, notwithstanding the justice of his cause, they had not virtue enough effectually to support him. Jugurtha's ambassadors, by distributing vast sums of money amongst the senators, brought them so far over, that a majority palliated his inhuman proceedings. This encouraged those ministers to declare, that Hiempsal had been killed by the Numidians on account of his excessive cruelty; that Adherbal was the aggressor in the late troubles; and that he was only chagrined because he could not make that havoc among his countrymen he would willingly have done. They therefore intreated the senate to form a judgment of Jugurtha's behaviour in Africa from his conduct at Numantia, rather than from the suggestions of his enemies. Upon which, by far the greatest part of the senate discovered themselves prejudiced in his favour. A few, however, that were not lost to honour, nor abandoned to corruption, insisted upon bringing him to condign punishment. But as they could not prevail, he had the best part of Numidia allotted him, and Adherbal was forced to rest satisfied with the other.

10.
One of
whom he
murders,
and drives
out the
other.

11.
Venality of
the Ro-
mans.

Jugurtha finding now by experience that every thing was venal at Rome, as his friends at Numantia had before informed him, thought he might pursue his towering projects without any obstruction from that quarter. He therefore, immediately after the last division of Micipsa's dominions, threw off the mask, and attacked his cousin by open force. As Adherbal was a prince of a pacific disposition, and almost in all respects the reverse of Jugurtha, he was by no means a match for him. The latter therefore pillaged the former's territories, stormed several of his fortresses, and over-ran a good part of his kingdom without opposition. Adherbal, depending on the friendship of the

Romans, which his father in his last moments assured him would be a stronger support to him than all the troops and treasures in the universe, dispatched deputies to Rome to complain of these hostilities. But whilst he lost his time in sending thither fruitless deputations, Jugurtha overthrew him in a pitched battle, and soon after shut him up in Cirta. During the siege of this city, a Roman commission arrived there, in order to persuade both parties to an accommodation; but finding Jugurtha untractable, the commissioners returned home without so much as conferring with Adherbal. A second deputation, composed of senators of the highest distinction, with Æmilius Scaurus, president of the senate, at their head, landed some time after at Utica, and summoned Jugurtha to appear before them. That prince at first seemed to be under dreadful apprehensions, especially as Scaurus reproached him with his enormous crimes, and threatened him with the resentment of the Romans if he did not immediately raise the siege of Cirta. However, the Numidian, by his address, and the irresistible power of gold, as was afterwards suspected at Rome, so mollified Scaurus, that he left Adherbal at his mercy. In fine, Jugurtha had at last Cirta surrendered to him, upon condition only that he should spare the life of Adherbal. But the merciless tyrant, in violation of the laws of nature and humanity as well as the capitulation, when he had got possession of the town, ordered him to be put to a most cruel death. The merchants likewise, and all the Numidians in the place capable of bearing arms, he caused without distinction to be put to the sword.

Every person at Rome inspired with any sentiments of humanity, was struck with horror at the news of this tragical event. However, all the venal senators still concurred with Jugurtha's ministers in palliating his enormous crimes. Notwithstanding which, the people, excited thereto by Caius Memmius their tribune, who bitterly inveighed against the venality of the senate, resolved not to let so flagrant an instance of villainy go unpunished. This disposition in them induced the conscript fathers likewise to declare their intention to chastise Jugurtha. In order to this, an army was levied to invade Numidia, and the command of it given to the consul Calpurnius Bestia, a person of good abilities, but rendered unfit for the expedition he was to go upon by his insatiable avarice. Jugurtha being informed of the great preparations making at Rome to attack his dominions, sent his son thither to avert the impending storm. The young prince was plentifully supplied with money, which he had orders to distribute liberally amongst the leading men. But Bestia, proposing to himself great advantages from an invasion of Numidia, defeated all his intrigues, and got a decree passed, ordering him and his attendants to depart Italy in ten days, unless they were come to deliver up the king himself, and all his territories, to the republic by way of dedition. Which decree being notified to them, they returned without so much as having entered the gates of Rome; and the consul soon after landed with a powerful army in Africa. For some time he carried on the war there very briskly, reduced several strong-holds, and took many Numidians prisoners. But upon the arrival of Scaurus, a peace was granted Jugurtha upon advantageous terms.

That

Numidia. That prince coming from Vacca, the place of his residence, to the Roman camp, in order to confer with Bestia and Scaurus, and the preliminaries of the treaty being immediately after settled between them in private conferences, every body at Rome was convinced that the prince of the senate and the consul had to their avarice sacrificed the republic. The indignation therefore of the people in general displayed itself in the strongest manner. Memmius also fired them with his speeches. It was therefore resolved to dispatch the prætor Cassius, a person they could confide in, to Numidia, to prevail upon Jugurtha to come to Rome, that they might learn from the king himself which of their generals and senators had been seduced by the pestilent influence of corruption. Upon his arrival there, he found means to bribe one Bæbius Salca, a man of great authority amongst the plebeians, but of insatiable avarice, by whose assistance he escaped with impunity. Nay, by the efficacy of gold, he not only eluded all the endeavours of the people of Rome to bring him to justice, but likewise enabled Bomilcar, one of his attendants, to get Massiva, an illegitimate son of Micipsa, assassinated in the streets of Rome. That young prince was advised by many Romans of probity, well-wishers to the family of Masinissa, to apply for the kingdom of Numidia; which coming to Jugurtha's ears, he prevented the application by this execrable step. However, he was obliged to leave Italy immediately.

Jugurtha had scarce set foot in Africa, when he received advice that the senate had annulled the shameful peace concluded with him by Bestia and Scaurus. Soon after, the consul Albinus transported a Roman army into Numidia, flattering himself with the hopes of reducing Jugurtha to reason before the expiration of his consulate. In this, however, he found himself deceived; for that crafty prince, by various artifices so amused and imposed upon Albinus, that nothing of moment happened that campaign. This rendered him strongly suspected of having betrayed his country, after the example of his predecessors. His brother Aulus, who succeeded him in the command of the army, was still more unsuccessful; for after rising from before Suthul, where the king's treasures were deposited, he marched his forces into a defile out of which he found it impossible to extricate himself. He therefore was obliged to submit to the ignominious ceremony of passing under the *jugum*, with all his men, and to quit Numidia entirely in ten days time, in order to deliver his troops from immediate destruction. The avaricious disposition of the Roman commander had prompted him to besiege Suthul, the possession of which place he imagined would make him master of all the wealth of Jugurtha, and consequently paved the way to such a scandalous treaty. However, this was declared void as soon as known at Rome, as being concluded without the authority of the people. The Roman troops retired into Africa Propria, which they had now reduced into the form of a Roman province, and there took up their winter quarters.

In the mean time Caius Mamilius Limetanus, tribune of the people, excited the plebeians to inquire into the conduct of those persons by whose assistance Jugurtha had found means to elude all the decrees of the senate. This put the body of the people into a

great ferment; which occasioned a prosecution of the guilty senators, that was carried on, for some time, with the utmost heat and violence. Lucius Metellus¹² the consul, during these transactions, had Numidia¹² assigned him for his province, and consequently was sent against Jugurtha. As he perfectly disregarded wealth, the Numidian found him superior to all his temptations; which was a great mortification to him. To this he joined all the other virtues which constitute the great captain; so that Jugurtha found him in all respects inaccessible. That prince therefore was now forced to regulate his conduct according to the motions of Metellus, with the greatest caution; and to exert his utmost bravery, in order to compensate for that hitherto so favourable expedient which now began to fail him. Marius, Metellus's lieutenant, being likewise a person of uncommon merit, the Romans reduced Vacca, a large opulent city, and the most celebrated mart in Numidia. They also defeated Jugurtha in a pitched battle; overthrew Bomilcar, one of his generals, upon the banks of the Muthullus; and, in fine, forced the Numidian monarch to take shelter in a place rendered almost inaccessible by the rocks and woods with which it was covered. However, Jugurtha signified himself in a surprising manner, exhibiting all that could be expected from the courage, abilities, and attention of a consummate general, to whom despair administers fresh strength, and suggests new lights. But his troops could not make head against the Romans; they were again worsted by Marius, though they obliged Metellus to raise the siege of Zama. Jugurtha therefore, finding his country every where ravaged, his most opulent cities plundered, his fortresses reduced, his towns burnt, vast numbers of his subjects put to the sword and taken prisoners, began to think seriously of coming to an accommodation with the Romans. His favourite Bomilcar, in whom he reposed the highest confidence, but who had been gained over to the enemy by Metellus, observing this disposition, found it no difficult matter to persuade him to deliver up his elephants, money, arms, horses, and deserters, in whom the main strength of his army consisted, into the hands of the Romans. Some of these last, in order to avoid the punishment due to their crime, retired to Bocchus king of Mauritania, and listed in his service. But Metellus ordering him to repair to Tifidum, a city of Numidia, there to receive farther directions, and he refusing a compliance with that order, hostilities were renewed with greater fury than ever. Fortune now seemed to declare in favour of Jugurtha: he retook Vacca, and massacred all the Roman garrison, except Turpilius the commandant. However, soon after, a Roman legion seized again upon it, and treated the inhabitants with the utmost severity. About this time, one of Masinabal's sons, named *Gauda*, whom Micipsa in his will had appointed to succeed to the crown in case his two legitimate sons and Jugurtha died without issue, wrote to the senate in favour of Marius, who was then endeavouring to supplant Metellus. That prince having his understanding impaired by a declining state of health, fell a more easy prey to the base and infamous adulation of Marius. The Roman, soothing his vanity, assured him, that as he was the next heir to the crown, he might depend upon being fixed

¹³ Who is betrayed by Bomilcar.

Numidia.
14
A conspiracy against him.

fixed upon the Numidian throne, as soon as Jugurtha was either killed or taken; and that this must in a short time happen, when once he appeared at the head of the Roman army with an unlimited commission. Soon after, Bomilcar and Nabdalsa formed a design to assassinate Jugurtha, at the instigation of Metellus; but this being detected, Bomilcar and most of his accomplices suffered death. The plot however had such an effect upon Jugurtha, that he enjoyed afterwards no tranquillity or repose. He suspected persons of all denominations, Numidians as well as foreigners, of some black designs against him. Perpetual terrors sat brooding over his mind; inasmuch that he never got a wink of sleep but by stealth, and often changed his bed in a low plebeian manner. Starting from his sleep, he would frequently snatch his sword, and break out into the most doleful cries: So strongly was he haunted by a spirit of fear, jealousy, and distraction!

15
He is defeated by Metellus.

Jugurtha having destroyed great numbers of his friends on suspicion of their having been concerned in the late conspiracy, and many more of them deserting to the Romans and Bocchus king of Mauritania, he found himself, in a manner, destitute of counsellors, generals, and all persons capable of assisting him in carrying on the war. This threw him into a deep melancholy, which rendered him dissatisfied with every thing, and made him fatigue his troops with a variety of contradictory motions. Sometimes he would advance with great celerity against the enemy, and at others retreat with no small swiftness from them. Then he resumed his former courage; but soon after despaired either of the valour or fidelity of the forces under his command. All his movements therefore proved unsuccessful, and at last he was forced by Metellus to a battle. That part of the Numidian army which Jugurtha commanded, behaved with some resolution; but the other fled at the first onset. The Romans therefore entirely defeated them, took all their standards, and made a few of them prisoners. But few of them were slain in the action; since, as Sallust observes, the Numidians trusted more to their heels than to their arms for safety in this engagement.

Metellus pursued Jugurtha and his fugitives to Thala. His march to this place being through vast deserts, was extremely tedious and difficult. But being supplied with leathern bottles and wooden vessels of all sizes taken from the huts of the Numidians, which were filled with water brought by the natives, who had submitted to him, he advanced towards that city. He had no sooner begun his march, than a most copious shower of rain, a thing very uncommon in those deserts, proved a great and seasonable refreshment to his troops. This so animated them, that upon their arrival before Thala, they attacked the town with such vigour, that Jugurtha, with his family, and treasures deposited therein, thought proper to abandon it. After a brave defence, it was reduced; the garrison, consisting of Roman deserters, setting fire to the king's palace, and consuming themselves, together with every thing valuable to them, in the flames. Jugurtha, being now reduced to great extremities, retired into Gætulia, where he formed a considerable corps. From thence he advanced to the confines of Mauritania; and engaged Bocchus king of that country, who had married his daughter, to enter

Numidia.

into an alliance with him. In consequence of which, having reinforced his Gætulian troops with a powerful body of Mauritanians, he turned the tables upon Metellus, and obliged him to keep close within his entrenchments. Sallust informs us, that Jugurtha bribed Bocchus's ministers to influence that prince in his favour; and that having obtained an audience, he insinuated, that, should Numidia be subdued, Mauritania must be involved in its ruin, especially as the Romans seemed to have vowed the destruction of all the thrones in the universe. In support of what he advanced, he produced several instances very apposite to the point in view. However, the same author seems to intimate, that Bocchus was determined to assist Jugurtha against his enemies by the slight the Romans had formerly shown him. That prince, at the first breaking out of the war, had sent ambassadors to Rome, to propose an offensive and defensive alliance to the republic; which, though of the utmost consequence to it at that juncture, a few of the most venal and infamous senators, who were abandoned to corruption, prevented from taking effect. This undoubtedly wrought more powerfully upon Bocchus in favour of Jugurtha, than the relation he stood in to him: For both the Moors and Numidians adapted the number of their wives to their circumstances, so that some had 10, 20, &c. to their share; their kings therefore were unlimited in this particular, and of course all degrees of affinity resulting to them from marriage had little force. It is observable, that the posterity of those ancient nations have the same custom prevailing amongst them at this day.

16

Such was the situation of affairs in Numidia, when Metellus received advice of the promotion of Marius to the consulate. But, notwithstanding this injurious treatment, he generously endeavoured to draw off Bocchus from Jugurtha, though this would facilitate the reduction of Numidia for his rival. To this end ambassadors were dispatched to the Mauritanian court, who intimated to Bocchus, "That it would be highly imprudent to come to a rupture with the Romans without any cause at all; and that he had now a fine opportunity of concluding a most advantageous treaty with them, which was much preferable to a war. To which they added, that whatever dependence he might place upon his riches, he ought not to run the hazard of losing his dominions by embroiling himself with other states, when he could easily avoid this; that it was much easier to begin a war than to end it, which it was in the power of the victor alone to do; that, in fine, he would by no means consult the interest of his subjects if he followed the desperate fortunes of Jugurtha." To which Bocchus replied, "That for his part there was nothing he wished for more than peace; but that he could not help pitying the deplorable condition of Jugurtha; that if the Romans, therefore, would grant that unfortunate prince the same terms they had offered him, he would bring about an accommodation." Metellus let the Mauritanian monarch know, that it was not in his power to comply with what he desired. However, he took care to keep up a private negotiation with him till the new consul Marius's arrival. By this conduct he served two wise ends. First, he prevented thereby Bocchus from coming to a general action with his troops;

Numidia. troops; which was the very thing Jugurtha desired, as hoping that this, whatever the event might be, would render a reconciliation betwixt him and the Romans impracticable. Secondly, this inaction enabled him to discover something of the genius and disposition of the Moors; a nation of whom the Romans, till then, had scarce formed any idea; which, he imagined, might be of no small service, either to himself or his successors, in the future prosecution of the war.

Jugurtha, being informed that Marius, with a numerous army, was landed at Utica, advised Bocchus to retire, with part of the troops, to some place of difficult access, whilst he himself took post upon another inaccessible spot with the remaining corps. By this measure, he hoped the Romans would be obliged to divide their forces, and consequently be more exposed to his efforts and attacks. He likewise imagined, that seeing no formidable body appear, they would believe the enemy in no condition to make head against them; which might occasion a relaxation of discipline, the usual attendant of a too great security, and consequently produce some good effect. However, he was disappointed in both these views. For Marius, far from suffering a relaxation of discipline to take place, trained up his troops, which consisted chiefly of new levies, in so perfect a manner, that they were soon equal in goodness to any consular army that ever appeared in the field. He also cut off great numbers of the Gætulian marauders, defeated many of Jugurtha's parties, and had like to have taken that prince himself near the city of Cirta. These advantages, though not of any great importance, intimidated Bocchus, who now made overtures for an accommodation; but the Romans, not being sufficiently satisfied of his sincerity, paid no great attention to them. In the mean time Marius pushed on his conquests, reducing several places of less note, and at last resolved to besiege Capsa. That this enterprise might be conducted with the greater secrecy, he suffered not the least hint of his design to transpire, even amongst any of his officers. On the contrary, in order to blind them, he detached A. Manlius, one of his lieutenants, with some light-armed cohorts, to the city of Lares, where he had fixed his principal magazine, and deposited the military chest. Before Manlius left the camp, that he might the more effectually amuse him, he intimated, that himself with the army should take the same route in a few days: but instead of that, he bent his march towards the Tanais, and in six days time arrived upon the banks of that river. Here he pitched his tents for a short time, in order to refresh his troops; which having done, he advanced to Capsa, and made himself master of it. As the situation of this city rendered it extremely commodious to Jugurtha, whose plan of operations, ever since the commencement of the war, it had exceedingly favoured, he levelled it with the ground after it had been delivered up to the soldiers to be plundered. The citizens likewise, being more strongly attached to that prince than any of the other Numidians, on account of the extraordinary privileges he indulged them with, and of course bearing a more implacable hatred to the Romans, he put to the sword or sold for slaves. The true motive of the consul's conduct

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on this occasion seems here to be assigned; though we are told by Sallust, in conformity to the Roman genius, that neither avarice nor resentment prompted him to so barbarous an action, but only a desire to strike a terror into the Numidians.

The Numidians, ever after this exploit, dreaded the very name of Marius; who now, in his own opinion, had eclipsed the glory of all his predecessor's great achievements, particularly the reduction of Thala, a city, in strength and situation, nearly resembling Capsa. Following his blow, he gradually presented himself before most of the places of strength in the enemy's country; many of which either opened their gates, or were abandoned, at his approach, being terrified with what had happened to the unfortunate citizens of Capsa. Others taken by force, he laid in ashes; and in short, filled the greatest part of Numidia with blood, horror, and confusion. Then, after an obstinate defence, he reduced a castle that seemed impregnable, seated not far from Mulucha, where Jugurtha kept part of his treasures. In the mean time, Jugurtha not being able to prevail upon Bocchus, by his repeated solicitations, to advance into Numidia, where he found himself greatly pressed, was obliged to have recourse to his usual method of bribing the Mauritanian ministers, in order to put that prince in motion. He also promised him a third part of his kingdom, provided they could either drive the Romans out of Africa, or get all the Numidian dominions confirmed to him by treaty.

So considerable a cession could not fail of engaging Bocchus to support Jugurtha with his whole power. The two African monarchs therefore, having joined their forces, surprised Marius near Cirta as he was going into winter-quarters. The Roman general was so pushed on this occasion, that the barbarians thought themselves certain of victory, and doubted not but they should be able to extinguish the Roman name in Numidia. But their incaution and too great security enabled Marius to give them a total defeat; which was followed four days after by so complete an overthrow, that their numerous army, consisting of 90,000 men, by the accession of a powerful corps of Moors, commanded by Bocchus's son Volux, was entirely ruined. Sylla, Marius's lieutenant, most eminently distinguished himself in the last action, which laid the foundation of his future greatness. Bocchus, now looking upon Jugurtha's condition as desperate, and not being willing to run the risk of losing his dominions, showed a disposition to clap up a peace with Rome. However, the republic gave him to understand, that he must not expect to be ranked amongst its friends, till he had delivered up into the consul's hands Jugurtha, the inveterate enemy of the Roman name. The Mauritanian monarch, having entertained an high idea of an alliance with that state, resolved to satisfy it in this particular; and was confirmed in his resolution by one Dabar, a Numidian prince, the son of Massugrada, and descended by his mother's side from Masinissa. Being closely attached to the Romans, and extremely agreeable to Bocchus on account of his noble disposition, he defeated all the intrigues of Aspar, Jugurtha's minister. Upon Sylla's arrival at the Mauritanian court, the affair there seemed to be entirely settled. However, Bocchus, who was for ever projecting new designs,

17
He gains
a great ad-
vantage
over Jugur-
tha.

18
Jugurtha
entirely de-
feated.

Numidia. designs, and, like the rest of his countrymen, in the highest degree perfidious, debated within himself, whether he should sacrifice Sylla or Jugurtha, who were both then in his power. He was a long time fluctuating with uncertainty, and combated by a contrariety of sentiments. The sudden changes which displayed themselves in his countenance, his air, and his whole person, evidently showed how strongly his mind was agitated. But at last he returned to his first design, to which the bias of his mind seemed naturally to lead him. He therefore delivered up Jugurtha into the hands of Sylla, to be conducted to Marius; who, by that successful event, happily terminated this dangerous war. The kingdom of Numidia was now reduced to a new form: Bocchus, for his important services, had the country of the Massæyli, contiguous to Mauritania, assigned him; which, from this time, took the name of *New Mauritania*. Numidia Propria, or the country of the Massyli, was divided into three parts; one of which was given to Hiempsal, another to Mandrestal, both descendants of Masinissa; and the third the Romans annexed to Africa Propria, or the Roman province adjacent to it. What became of Jugurtha after he had graced Marius's triumph, at which ceremony he was led in chains, together with his two sons, through the streets of Rome, we have already laid before our readers. See JUGURTHA.

²⁰ Transac-
tions after
the death of
Jugurtha. Jugurtha's two sons survived him, but spent their lives in captivity at Venusia. However, one of them, named *Oxyntas*, was, for a short time, released from his confinement by Aponius, who besieged Accerræ in the war between the Romans and the Italian allies. That general brought this prince to his army, where he treated him as king, in order to draw the Numidian forces off from the Roman service. Accordingly those Numidians no sooner heard that the son of their old king was fighting for the allies, than they began to desert by companies; which obliged Julius Cæsar the consul to part with all his Numidian cavalry, and send them back into Africa. Some few years after this event, Pompey defeated Cneius Domitius Ahenobarbus, and Hiarbas, one of the kings of Numidia, killing 17,000 of their men upon the spot. Not satisfied with this victory, that general pursued the fugitives to their camp, which he soon forced, put Domitius to the sword, and took Hiarbas prisoner. He then reduced that part of Numidia which belonged to Hiarbas, who seems to have succeeded Mandrestal above-mentioned; and gave it to Hiempsal, a neighbouring Numidian prince, descended from Masinissa, who had always opposed the Marian faction.

²¹ Cæsar in-
sults Juba. Suetonius informs us, that a dispute happened between Hiempsal and one Masintha, a noble Numidian, whom, it is probable, he had in some respect injured when Julius Cæsar first began to make a figure in the world. The same author adds, that Cæsar warmly espoused the cause of Masintha, and even grossly insulted Juba, Hiempsal's son, when he attempted to vindicate his father's conduct on this occasion. He pulled him by the beard, than which a more unpardonable affront could not be offered to an African. In short, he screened Masintha from the insults and violence of his enemies; from whence a reason may be as-

signed for Juba's adhering so closely afterwards to the Pompeian faction. ²² Juba de-
feats one of
Cæsar's
lieutenants.

In consequence of the indignity Cæsar had offered Juba, and the disposition it had occasioned, that prince did Cæsar great damage in the civil wars betwixt him and Pompey. By a stratagem he drew Curio, one of his lieutenants, into a general action, which it was his interest at that time to have avoided. He caused it to be given out all over Africa Propria and Numidia, that he was retired into some remote country at a great distance from the Roman territories. This coming to Curio's ears, who was then besieging Utica, it hindered him from taking the necessary precautions against a surprise. Soon after, the Roman general receiving intelligence that a small body of Numidians was approaching his camp, he put himself at the head of his forces in order to attack them, and, for fear they should escape, began his march in the night, looking upon himself as sure of victory. Some of their advanced posts he surprised asleep, and cut them to pieces; which still farther animated him. In short, about day-break he came up with the Numidians, whom he attacked with great bravery, though his men were then fasting, and vastly fatigued by their forced and precipitate march. In the mean time, Juba, who, immediately after the propagation of the rumour above-mentioned, had taken care to march privately, with the main body of the Numidian army, to support the detachment sent before to decoy Curio, advanced to the relief of his men. The Romans had met with a great resistance before he appeared; so that he easily broke them, killed Curio, with a great part of his troops, upon the spot, pursued the rest to their camp, which he plundered, and took many of them prisoners. Most of the fugitives, who endeavoured to make their escape on board the ships in the port of Utica, were either slain by the pursuers, or drowned. The remainder fell into the hands of Varus, who would have saved them; but Juba, who arrogated to himself the honour of this victory, ordered most of them to be put to the sword.

²³ Juba over-
thrown by
Cæsar. This victory infused new life and vigour into the Pompeian faction, who thereupon conferred great honours upon Juba, and gave him the title of *king of all Numidia*. But Cæsar and his adherents declared him an enemy to the state of Rome, adjudging to Bocchus and Bogud, two African princes entirely in their interest, the sovereignty of his dominions. Juba afterwards, uniting his forces with those of Scipio, reduced Cæsar to great extremities, and would in all probability have totally ruined him, had he not been relieved by Publius Sittius. That general, having formed a considerable corps, consisting of Roman exiles, and Mauritanian troops sent him by Bocchus, according to Dio, or, as Cæsar will have it, Bogud, made an irruption into Gætulia and Numidia, whilst Juba was employed in Africa Propria. As he ravaged these countries in a dreadful manner, Juba immediately returned with the best part of his army, to preserve them from utter destruction. However, Cæsar knowing his horse to be afraid of the enemy's elephants, did not think proper to attack Scipio in the absence of the Numidian, till his own elephants, and a fresh reinforcement of troops, hourly expected, arrived from Italy.

Numidia

Italy. With this accession of strength, he imagined himself able to give a good account, both of the Roman forces with which he was to cope, and the barbarians. In the mean time Scipio dispatched reiterated expresses to Juba to hasten to his assistance; but could not prevail upon him to move out of Numidia, till he had promised him the possession of all the Roman dominions in Africa, if they could from thence expel Cæsar. This immediately put him in motion; so that, having sent a large detachment to make head against Sittius, he marched with the rest of his troops to assist Scipio. However, Cæsar at last overthrew Scipio, Juba, and Labienus, near the town of Thapsus, and forced all their camps. As Scipio was the first surprised and defeated, Juba fled into Numidia, without waiting for Cæsar's approach; but the body of the Numidians detached against Sittius, having been broken and dispersed by that general, none of his subjects there would receive him. Abandoned therefore to despair, he sought death in a single combat with Petreius, and, having killed him, caused himself to be dispatched by one of his slaves.

24
Numidia
reduced to
the form of
a province.

After this decisive action, and the reduction of Africa Propria, Cæsar made himself master of Numidia, which he reduced to a Roman province, appointing Crispus Sallustius to govern it in quality of proconsul, with private instructions to pillage and plunder the inhabitants, and, by that means, put it out of their power ever to shake off the Roman yoke. However, Bocchus and Bogud still preserved a sort of sovereignty in the country of the Massæyli and Mauritania, since the former of those princes, having deserted Cæsar, sent an army into Spain to assist the Pompeians; and the latter, with his forces, determined victory to declare for Cæsar at the ever memorable battle of Munda. Bogud, afterwards siding with Antony against Octavius, sent a body of forces to assist him in Spain; at which time the Tingitanians revolting from him, Bocchus, with an army composed of Romans in the interest of Octavius, who passed over from Spain into Africa, and his own subjects, possessed himself of Mauritania Tingitana. Bogud fled to Antony; and Octavius, after the conclusion of the war, honoured the inhabitants of Tingi with all the privileges of Roman citizens. He likewise confirmed Bocchus king of Mauritania Cæsariensis, or the country of the Massæyli, in the possession of Tingitania, which he had conquered, as a reward for his important services. In this he imitated the example of his great predecessor Julius Cæsar, who divided some of the fruitful plains of Numidia among the soldiers of P. Sittius, who had conquered great part of that country, and appointed Sittius himself sovereign of that district. Sittius, as has been intimated above, having taken Cirta, killed Sabura, Juba's general, entirely dispersed his forces, and either cut off or taken prisoners most of the Pompeian fugitives that escaped from the battle of Thapsus, highly deserved to be distinguished in so eminent a manner. After Bocchus's death, Mauritania and the Massæylian Numidia were in all respects considered as Roman provinces.

NUMISMATOGRAPHIA, a term used for the description and knowledge of ancient coins and medals, whether of gold, silver, or brass. See COINS and MEDALS.

NUMITOR, the son of Procas king of Alba, and the brother of Amulius. Procas before his death made him and Amulius joint heirs to the crown, on condition of their reigning annually by turns: but Amulius, on getting possession of the throne, excluded Numitor, whose son Lausus he ordered to be put to death, and obliged Rhea Sylvia, Numitor's only daughter, to become a vestal. This princess becoming pregnant, declared that she was with child by the god Mars; and afterwards brought forth Rhemus and Romulus, who at length killed Amulius, and restored Numitor to the throne, 754 B. C. See RHEMUS and ROMULUS.

NUMMUS, a piece of money otherwise called *sestertius*.

NUN, the son of Elishamah, and father of Joshua, of the tribe of Ephraim. The Greeks gave him the name of *Nave* instead of Nun. This man is known in sacred history only by being the father of Joshua.

NUN, a woman, in several Christian countries, who devotes herself, in a cloister or nunnery, to a religious life. See the article MONK.

There were women, in the ancient Christian church, who made public profession of virginity, before the monastic life was known in the world, as appears from the writings of Cyprian and Tertullian. These, for distinction's sake, are sometimes called *ecclesiastical virgins*, and were commonly enrolled in the canon or matricula of the church. They differed from the monastic virgin chiefly in this, that they lived privately in their fathers houses, whereas the others lived in communities: but their profession of virginity was not so strict as to make it criminal in them to marry afterwards, if they thought fit. As to the consecration of virgins, it had some things peculiar in it: it was usually performed publicly in the church by the bishop. The virgin made a public profession of her resolution, and then the bishop put upon her the accustomed habit of sacred virgins. One part of this habit was a veil, called the *sacrum velamen*; another was a kind of mitre or coronet worn upon the head. At present, when a woman is to be made a nun, the habit, veil, and ring of the candidate are carried to the altar; and she herself, accompanied by her nearest relations, is conducted to the bishop, who, after mass and an anthem, (the subject of which is, "that she ought to have her lamp lighted, because the bridegroom is coming to meet her"), pronounces the benediction: then she rises up, and the bishop consecrates the new habit, sprinkling it with holy water. When the candidate has put on her religious habit, she presents herself before the bishop, and sings, on her knees, *Ancilla Christi sum*, &c.; then she receives the veil, and afterwards the ring, by which she is married to Christ; and lastly, the crown of virginity. When she is crowned, an anathema is denounced against all who shall attempt to make her break her vows. In some few instances, perhaps, it may have happened that nunneries, monasteries, &c. may have been useful as well to morality and religion as to literature: in the gross, however, they have been highly prejudicial; and however well they might be supposed to do when viewed in theory, in fact they are unnatural and impious. It was surely far from the intention of Providence to seclude youth and beauty in a cloistered ruin, or to deny them the innocent enjoyment of their years and sex.

Numitor
||
Nun.

Nuncio
il
Monte
Nuovo.

NUNCIO, or **NUNTIO**, an ambassador from the pope to some Catholic prince or state, or a person who attends on the pope's behalf at a congress, or an assembly of several ambassadors.

NUNCUPATIVE, in the schools, something that is only nominal, or has no existence but in name.

NUNCUPATIVE Will or Testament, a will made verbally, and not put in writing. See the articles **WILL** and **TESTAMENT**.

NUNDINA, a goddess among the ancient heathens, supposed to have the care of the purification of infants. And because male infants were purified nine days after their birth, her name is derived from *nonus*, or the ninth, though female-infants were purified the eighth day; which purification was called *lustration* by the Romans.

NUNDINAL, *Nundinalis*, a name which the Romans gave to the eight first letters of the alphabet used in their kalendar.

This series of letters, A, B, C, D, E, F, G, H, is placed and repeated successively from the first to the last day of the year: one of these always expressed the market-days, or the assemblies called *nundinae*, *quasi novendinae*, because they returned every nine days. The country people, after working eight days successively, came to town the ninth, to sell their several commodities, and to inform themselves of what related to religion and government. Thus the nundinal day being under A on the first, ninth, seventeenth, and twenty-fifth days of January, &c. the letter D will be the nundinal letter of the year following. These nundinals bear a very great resemblance to the dominical letters, which return every eight days, as the nundinals did every nine.

NUNDOCOMAR, a Rajah in Bengal, and head of the Bramins, who, in 1775, was condemned to an ignominious death by English laws newly introduced, in an English court of justice newly established, for a forgery charged to have been committed by him many years before. That he was guilty of the deed cannot be questioned; but there was surely something hard in condemning a man by an *ex post facto* law. He bore his fate with the utmost fortitude, in the full confidence that his soul would soon be reunited to the universal spirit whence it had sprung. See **METAPHYSICS**, Part III. Ch. iv. *Of the Immortality of the Soul*.

Monte Nuovo, in the environs of Naples, blocks up the valley of Averno. "This mountain (Mr Swinburne tells us) arose in the year 1538, for after repeated quakings the earth burst asunder, and made way for a deluge of hot ashes and flames, which rising extremely high, and darkening the atmosphere, fell down again and formed a circular mound four miles in circumference, and 1000 feet high, with a large cup in the middle. The wind rising afterwards, wafted the lighter particles over the country, blasted vegetation, and killed the animals who grazed; the con-

sequence was, that the place was deserted, till Don Pedro de Toledo, viceroy of Naples, encouraged the inhabitants by example and otherwise to return.

"Part of Monte Nuovo is cultivated, but the larger portion of its declivity is wildly overgrown with prickly-broom, and rank weeds that emit a very fetid sulphureous smell. The water is shallow, its inside clad with shrubs, and the little area at the bottom planted with fig and mulberry trees; a most striking specimen of the amazing vicissitudes that take place in this extraordinary country. I saw no traces of lava or melted matter, and few stones within.

"Near the foot of this mountain the subterraneous fires act with such immediate power, that even the sand at the bottom of the sea is heated to an intolerable degree."

NUPTIAL RITES, the ceremonies attending the solemnization of marriage, which are different in different ages and countries. We cannot omit here a custom which was practised by the Romans on these occasions; which was this: Immediately after the chief ceremonies were over, the new-married man threw nuts about the room for the boys to scramble for. Various reasons have been assigned for it; but that which most generally prevails, and seems to be the most just, is, that by this act the bridegroom signified his resolution to abandon trifles, and commence a serious course of life; whence *nucibus relictis* in this sense became a proverb. They might also be an emblem of fertility.

The ancient Greeks had a person to conduct the bride from her own to the bridegroom's house; and hence he was called by the Greeks *Nymphagogi*, which term was afterwards used both by the Romans and the Jews.

NUREMBERG, an imperial city of Germany, capital of a territory of the same name, situated in E. Long. 11°, N. Lat. 47.30. It stands on the Regnitz, over which it has several bridges, both of wood and stone, at the bottom of a hill, 60 miles from Augsburg, 87 from Munich, 46 from Wurtzburg, and 50 from Ratisbon; and is thought by some to be the Segodunum, and by others the Castrum Noricum, of the ancients.

The city has derived its name from the hill, upon which stands this castle, called, in Latin, Castrum Noricum, round which the city was begun to be built, and where the emperors formerly lodged; and here they lodge still, when they pass by that city. They there preserve, as precious relics, the crown, sceptre, cloaths, buskins, and other ornaments of Charlemagne (A), which served also the emperor Leopold, when he went thither after his election, to receive the homage of the city. The small river Regnitz, which runs through it, and those of Rednitz and Schwar-zack, which pass by its walls, furnish the inhabitants, besides other advantages, with the means of making all sorts of stuffs, dyes, and other manufactures (B),

U 2

and

Nuptial,
Nurem-
berg.

(A) These ornaments are, a mitred crown, enriched with rubies, emeralds, and pearls; the dalmatic of Charlemagne, richly embroidered; the imperial mantle powdered, with embroidered eagles, and its border thick set with large emeralds, sapphires, and topazes; the buskins covered with plates of gold; the gloves embroidered; the apple, the golden sceptre, and sword. The ancient custom of the empire is, that the emperor is bound to assemble in this city the first diet that he holds after his election and coronation.

(B) There is in Nuremberg, and in the neighbouring villages depending upon it, an infinite number of workmen

Nurem-
berg.

and toys, which are carried and sold even in the Indies.

It is a large and well-built town, but not very populous. Its fortifications are a double wall, flanked with towers mounting cannon, and a deep ditch. The magistrates, and most of the inhabitants, are Lutherans. There are a great many churches and chapels in it. In that of St Sebald is a brass monument of the saint; and a picture, representing the creation of the world, by the celebrated Albert Durer, who was a native of the town; but the finest church in the town is that of St Giles. In that of the Holy Ghost are kept most of the jewels of the empire, together with the pretended spear with which our Saviour's side was pierced, a thorn of his crown, and a piece of the manger wherein he was laid. Here are also a great many hospitals, one in particular for foundlings, and another for pilgrims; with a gymnasium, an anatomical theatre, a granary, a fine public library, the old imperial fortress or castle, some remains of the old citadel of the burgraves of Nuremberg, several Latin schools, an academy of painting, a well furnished arsenal, a Teutonic house in which the Roman-catholic service is tolerated, and a mint. Mr Keyser says, there are upwards of 500 streets in it, about 140 fountains, 16 churches, 44 religious houses, 12 bridges, 10 market-places, and 25,000 inhabitants; and that its territories, besides the capital and four other towns, contains above 500 villages, and about 160 mills on the Regnitz. The trade of this city, though upon the decline, is still very great, many of its manufactures being still exported to all parts of the world; among which may be reckoned a great variety of curious toys in ivory, wood, and metal, already mentioned. The city has also distinguished itself in the arts of painting and engraving. When the emperor Henry VI. assisted at a tournament in Nuremberg, he raised 38 burghers to the degree of nobility, the descendants of whom are called *patricians*, and have the government of the city entirely in their hands; the whole council, except eight masters of companies, who are summoned only on extraordinary occasions, consisting of them. Among the fine brass cannon in the arsenal, is one that is charged at the breech, and may be fired eight times in a minute; and two that carry balls of eighty pounds. The city keeps, in constant pay, seven companies, consisting each, in time of peace, of 100 men, but, in time of war, of 185; two troops of cuirassiers, each consisting of 85 men; and two companies of invalids. There are also 24 companies of burghers, well armed and disciplined. On the new bridge, which is said to have cost 100,000 guilders, are two pyramids, on the top of one of which is a dove with

an olive branch in her bill, and on the other an imperial black eagle. Music also flourishes greatly in Nuremberg; and those who delight in mechanic arts and manufactures cannot any where better gratify their curiosity. As an imperial city, it has a seat and voice at the diets of the empire and circle, paying to the chamber of Wetzlar 812 rix-dollars each term. The territory belonging to the city is pretty large, containing, besides two considerable forests of pine, called the *Sibald* and *Laurence forests*, several towns and villages.

We have mentioned already that certain families called patricians, to the exclusion of the rest, possess the offices of the senate. They are composed of 42 persons (c), over which two castellans, or perpetual seneschals, preside, the first of whom has his residence in the castle. These castellans assemble sometimes in the castle, with five or six of the chief members, to hold a secret council (d). And, as this city glories in being one of the first which embraced Lutheranism, it preserves the privilege of that in civil matters, not admitting any catholics to the magistracy or freedom of the town; the catholics there having the liberty only of remaining under the protection of the rest, and performing their religious worship in a commandery of Malta, and this but at certain hours, not to disturb the Lutherans, who likewise assemble there, although in possession of all the other churches.

This city is particularly noted for its antiquity, grandeur, fortifications, its triple walls of hewn stone, its large and deep moat, its fine houses, large churches, its wide streets, always clean, and for its curious and large library, and its magazine stored with every thing proper for its defence.

NURSERY, in gardening, is a piece of land set apart for raising and propagating all sorts of trees and plants to supply the garden and other plantations.

NURSING OF CHILDREN. See LACTATIO.

The following observations are said to be the result of long experience †. A child, when it comes into the world, is almost a round ball; it is the nurse's part to assist nature, in bringing it to a proper shape. The child should be laid (the first month) upon a thin matras, rather longer than itself, which the nurse will keep upon her lap, that the child may always lie straight, and only sit up as the nurse slants the matras. To set a child quite upright before the end of the first month, hurts the eyes, by making the white part of the eye appear below the upper eye-lid. Afterwards the nurse will begin to set it up and dance it by degrees. The child must be kept as dry as possible.

The cloathing should be very light, and not much longer than the child, that the legs may be got at with ease, in order to have them often rubbed in the day

Nurem-
berg
||
Nurling.† *An. Reg.*
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130.

workmen, very ingenious in making several kinds of toys of wood, which are carried through all the fairs of Germany, and from thence through all Europe. These toys are called Nurembergs; and they have so great a sale, that it even exceeds description. This employment affords a livelihood to the greatest part of the inhabitants of the city; and they make a very considerable profit from this traffic.

(c) Of these 42 members, there are only 34 chosen from the patrician families; the other eight are taken from among the burghers, and make in a manner a small separate body.

(d) This secret council is composed of seven principal chiefs of the republic, and for that reason is called *septemvirate*. It determines the most important affairs; and it is the depository of the precious stones of the empire, of the imperial crown, the ensigns, seals, and keys of the city.

Nursing. day with a warm hand or flannel, and in particular the inside of them.

Rubbing a child all over takes off scurf, and makes the blood circulate. The one breast should be rubbed with the hands one way, and the other the other way, night and morning at least.

The ankle-bones and inside of the knees should be rubbed twice a-day; this will strengthen those parts, and make the child stretch its knees and keep them flat, which is the foundation of an erect and graceful person.

A nurse ought to keep a child as little in her arms as possible, lest the legs should be cramped, and the toes turned inwards. Let her always keep the child's legs loose. The oftener the posture is changed, the better.

Tossing a child about, and exercising it in the open air in fine weather, is of the greatest service. In cities, children are not to be kept in hot rooms, but to have as much air as possible.

Want of exercise is the cause of large heads, weak and knotted joints, a contracted breast, which occasions coughs and stuffed lungs, an ill shaped person, and waddling gait, besides a numerous train of other ills.

The child's flesh is to be kept perfectly clean, by constantly washing its limbs, and likewise its neck and ears; beginning with warm water, till by degrees it will not only bear, but like to be washed with cold.

Rising early in the morning is good for all children, provided they awake of themselves, which they generally do; but they are never to be waked out of their sleep, and as soon as possible to be brought to regular sleeps in the day.

When laid in bed or cradle, their legs are always to be laid straight.

Children, till they are two or three years old, must never be suffered to walk long enough at a time to be weary.

Girls might be trained to the proper management of children, if a premium were given in free-schools, workhouses, &c. to those that brought up the finest child to one year old.

If the mother cannot suckle the child, get a wholesome cheerful woman, with young milk, who has been used to tend young children. After the first six months, small broths, and innocent foods of any kind, may do as well as living wholly upon milk.

A principal thing to be always attended to is, to give young children constant exercise, and to keep them in a proper posture.

With regard to the child's dress in the day, let it be a shirt; a petticoat of fine flannel, two or three inches longer than the child's feet, with a dimity top (commonly called a *bodice-coat*, to tie behind; over that a surcingle made of fine buckram, two inches broad, covered over with sattin or fine ticken, with a ribbon fastened to it to tie it on, which answers every purpose of stays, and has none of their inconveniences. Over this put a robe, or a slip and frock, or whatever you like best; provided it is fastened behind, and not much longer than the child's feet, that their motions may be strictly observed.

Two caps are to be put on the head, till the child has got most of its teeth.

The child's dress for the night may be a shirt, a blanket to tie on, and a thin gown to tie over the blanket.

NUSANCE, or **NUISANCE**, in law, a thing done to the annoyance of another.

Nuisances are either public or private.—A public nuisance is an offence against the public in general, either by doing what tends to the annoyance of all the king's subjects, or by neglecting to do what the common good requires: in which case, all annoyances and injuries to streets, highways, bridges, and large rivers, as also disorderly alehouses, bawdy-houses, gaming-houses, stages for rope-dancers, &c. are held to be common nuisances.—A private nuisance is, when only one person or family is annoyed by the doing of any thing; as where a person stops up the light of another's house, or builds in such a manner that the rain falls from his house upon his neighbour's.

NUT, among botanists, denotes a **PERICARPIUM** of an extraordinary hardness, inclosing a kernel or seed.

NUTATION, in astronomy, a kind of tremulous motion of the axis of the earth, whereby, in each annual revolution, it is twice inclined to the ecliptic, and as often returns to its former position.

NUTCRAKER. See **CORVUS**, n^o 8.

“This bird (says Buffon) is distinguished from the jays and magpies by the shape of its bill, which is straighter, blunter, and composed of two unequal pieces. Its instinct is also different; for it prefers the residence of high mountains, and its disposition is not so much tinged with cunning and suspicion.”

They live upon hazel-nuts, acorns, wild berries, the kernels of pine-tops, and even on insects.

“Besides the brilliancy of the plumage, the nutcracker is remarkable for the triangular white spots which are spread over its whole body, except the head. These spots are smaller on the upper part, and broader on the breast; their effect is the greater, as they are contrasted with the brown ground.

“These birds are most attached, as I have observed above, to mountainous situations. They are common in Auvergne, Savoy, Lorraine, Franche-Comté, Switzerland, the Bergamasque, in Austria, in the mountains which are covered with forests of pines. They also occur in Sweden, though only in the southern parts of that country. The people in Germany call them Turkey birds. Italian birds, African birds; which language means no more than that they are foreign.

“Though the nutcrackers are not birds of passage, they fly sometimes from the mountains to the plains. Frisch says, that flocks of them are often observed to accompany other birds into different parts of Germany, especially where there are pine forests. But in 1754, great flights of them entered France, particularly Burgundy, where there are few pines; they were so fatigued on their arrival, that they suffered themselves to be caught by the hand.

“We cannot find in writers of natural history any details with regard to their laying, their incubation, the training of their young, the duration of their life,

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Plate
CCCXLVIEA

Nuthatch, &c. for they haunt inaccessible spots, where they enjoy undisturbed safety and felicity."

NUTHATCH, in ornithology. See SITTA, its generic name. In this place we shall only extract from Buffon an account of two species of foreign birds related to the nuthatch.

1. *The great hook-billed nuthatch*.—"It is the largest of the known nuthatches: its bill, though pretty straight, is inflated at the middle, and a little hooked at the end; the nostrils are round; the quills of the tail and of the wings edged with orange on a brown ground; the throat white; the head and back gray; the under side of the body whitish. Such are the principal properties of the bird. It was observed by Sloane in Jamaica.

"Its total length is about seven inches and a half; the bill, is eight lines and one third; the upper mandible a little protuberant near the middle; the mid toe, eight lines and one third; the alar extent, eleven inches and a quarter; the tail about twenty-three lines."

Plate
CCCLVII *2. The spotted or Surinam nuthatch*.—"This is another American nuthatch, with a hooked bill; but differs from the preceding in size, plumage, and climate: it inhabits Dutch Guiana.

"The upper side of the head and of the body is of a dull ash colour; the superior coverts of the wings of the same colour, but terminated with white; the throat white; the breast and all the under side of the body cinereous, and more dilute than the upper side, with white streaks scattered on the breast and sides, which forms a sort of speckling; the bill and legs brown.

"Total length, about six inches; the bill, an inch; the *tarsus*, seven lines and a half; the mid toe, eight or nine lines, and longer than the hind toe, whose nail is the strongest; the tail, about eighteen lines, consisting of twelve nearly equal quills, and exceeds the wings thirteen or fourteen lines."

Plates
CCXXXIV
and
CCXXXV.

NUTMEG. See MYRISTICA, its generic name. The tree which produces this fruit was formerly thought to grow only in the Banda Islands. It is now past a doubt, however, that it grows in the Isle of France and in all or most of the isles of the south seas. It seems a little remarkable that this trade, which is certainly a lucrative one, should have been so long monopolized by the Dutch. Their cunning and desire to retain it in their own hands seems to account for the idea that so generally prevailed formerly that it grew only in their settlements. It was reported as early as the year 1751, upon what appeared at that time to be good grounds, that it was likely to be produced in the West Indies. An English sailor said he had seen some trees in Jamaica, and the governor on inquiry found it so, and that they agreed exactly with the description given of those in the Spice Islands in the East Indies. This account, which was given in the Gentleman's Magazine for January 1751, we have never seen confirmed; and therefore we suppose that the expectations formed were either frustrated or premature: however, it is certain, as we have observed under the generic name, that a wild species of it grows at Tobago. To avoid repetition, or the appearance of proximity, we must refer those who wish for farther information respecting the trade in this article to M. P. Sonnerat's account of a voyage to the Spice Islands

and New Guinea, which was printed at Paris in 1775, and translated into English and printed at Bury St Edmund's in 1781, &c. and to Bougainville's voyage, and Dr Hawkesworth's compilation of English voyages.

It will not, however, we trust, be deemed improper nor beside our purpose, if we lay before our readers the following account of the dangerous consequences of using this article to excess. It was given by Dr Jacob Schmidius, published in the Gentleman's Magazine for 1767.

"A gentleman of Lower Silesia, about thirty-six years old, of a good constitution, and who enjoyed a good state of health, having felt, during some days, some cholic pains, took it in his head, by way of remedy, to eat four nutmegs, which weighed all together two ounces, and he drank, in eating them, some glasses of beer; which he had no sooner done, but he was seized with a great heat, a violent pain in the head, a vertigo and delirium, and was instantly deprived of the use of sight, speech, and of all his senses. He was put to bed, where he remained two days and two nights; his body was oppressed with lassitude, always drowsy, yet without being able to sleep. The third day he was in that lethargic state, which is called a *coma vigil*, with a weak and intermitting pulse. Cephalic remedies, cordials, and among others the spirit of cephalic vitriol, and the essence of castoreum, were administered in good spirit of sal ammoniac. The fourth day he recovered a little, but had absolutely lost his memory, so as not to remember the least thing he had done in his life. A continued fever then came on, accompanied by an obstinate watchfulness; a palpitation of the heart seemed to be the fore-runner of other symptoms, and he was finally struck with a palsy in all his limbs.

"At the expiration of eight days, he recovered the use of reason, and said, that during the first four days of his illness, he seemed to himself to have constantly a thick veil before his eyes, and that a great number of sparks and flashes continually issued from it. All the bad symptoms of this malady yielded at last successively to the continued use of remedies suited to his condition; and in three months time he was perfectly recovered, but he was particularly indebted for his cure to mercurial and ammoniacal remedies.

"According to chemical principles, it might perhaps be said, that the aromatic and oily salt contained in nutmeg, of which this patient had taken too large a dose, had immediately excited so great an agitation in the humours, and so rapid a motion in the animal spirits, as in some measure to partake of the nature of fire, and that a viscid and narcotic sulphur, which resides likewise in the nutmeg, though in a less sensible manner, being carried at the same time into the mass of blood, by suddenly fixing the animal spirits, and intercepting their course in the nerves, had afterwards caused the stupor in the limbs, the aphony, and the palsy. But I leave others to explain these phenomena; my only view, by communicating this observation, being to show that the immoderate use of nutmeg may be attended with very great danger."

NUTRITION, in the animal-economy, is the repairing the continual loss which the different parts of the body undergo. The motion of the parts of the body,

Nutmeg. body, the friction of these parts with each other, and especially the action of the air, would destroy the body entirely, if the loss was not repaired by a proper diet, containing nutritive juices; which being digested in the stomach, and afterwards converted into chyle, mix with the blood, and are distributed through the whole body for its nutrition.

In young persons, the nutritive juices not only serve to repair the parts that are damaged, but also to increase them, which is called *growth*.

In grown persons, the cuticle is every where constantly desquamating, and again renewing; and in the same manner the parts rubbed off, or otherwise separated from the fleshy parts of the body, are soon supplied with new flesh; a wound heals, and an emaciated person grows plump and fat.

Buffon, in order to account for nutrition, supposes the body of an animal or vegetable to be a kind of mould, in which the matter necessary to its nutrition is modelled and assimilated to the whole. But (continues he) of what nature is this matter which an animal or vegetable assimilates to its own substance? What power is it that communicates to this matter the activity and motion necessary to penetrate this mould? and, if such a force exist, would it not be by a similar force that the internal mould itself might be reproduced?

As to the first question, he supposes that there exists in nature an infinite number of living organical parts, and that all organized bodies consist of such organical parts; that their production costs nature nothing, since their existence is constant and invariable; so that the matter which the animal or vegetable assimilates to its substance, is an organical matter of the same nature with that of the animal or vegetable, which consequently may augment its volume without changing its form or altering the quality of the substance in the mould.

As to the second question: There exist (says he) in nature certain powers, as that of gravity, that have no affinity with the external qualities of the body, but act upon the most intimate parts, and penetrate them throughout, and which can never fall under the observation of our senses.

And as to the third question, he answers, that the internal mould itself is reproduced, not only by a similar power, but it is plain that it is the very same power that causes the unfolding and reproduction thereof: for it is sufficient (proceeds he), that in an organized body that unfolds itself, there be some part similar to the whole, in order that this part may one day become itself an organized body, altogether like that of which it is actually a part.

NUX MOSCHATA. See MYRISTICA and NUTMEG.

Nux Pistachia. See PISTACHIA.

Nux Vomica, a flat, compressed, round fruit, about the breadth of a shilling, brought from the East Indies. It is found to be a certain poison for dogs, cats, &c. and it is not to be doubted that it would also prove fatal to mankind. Its surface is not much corrugated; and its texture is firm like horn, and of a pale greyish-brown colour. It is said to be used as a specific against the bite of a species of water-snake. It is considerably bitter and deleterious; but has been used in doses from five to ten grains twice a-day or so,

in intermittents, particularly obstinate quartans, and in contagious dysentery. The *Strychnus Ignatii* is a tree of the same kind producing gourd-like fruit, the seeds of which are improperly called St Ignatius's beans. These, as also the woods or roots of some such trees, called *lignum colubrinum* or *snake-wood*, are very narcotic bitters like the *nux vomica*.

NUYTS (Peter), a native of Holland, and a leading character in that extraordinary transaction which happened between the Japanese and the Dutch about the year 1628. In 1627 Nuyts arrived in Batavia from Holland, and was in the same year appointed ambassador to the Emperor of Japan by the governor and council of Batavia.

He repaired to that empire in 1628; and being a man of a haughty disposition, and extremely vain, he believed it practicable to pass upon the natives for an ambassador from the king of Holland. Upon his assuming this title he was much more honourably received, caressed, and respected, than former ministers had been. But he was soon detected, reprimanded, and reproached in the severest manner, sent back to the port, and ordered to return to Batavia with all the circumstances of disgrace imaginable; notwithstanding which, his interest was so great, that, instead of being punished as he deserved, he was immediately afterwards promoted to the government of the island of Formosa, of which he took possession the year following.

He entered upon the administration of affairs in that island with the same disposition that he had shown while ambassador, and with the most implacable resentment against the Japanese; neither was it long before an opportunity offered, as he thought, of revenging himself to the full. Two large Japanese ships, with upwards of five hundred men on board, came into the port; upon which he took it into his head to disarm and unrig them, in the same manner as the Dutch vessels are treated at Japan. The Japanese did all they could to defend themselves from this ill usage; but at last, for want of water, they were forced to submit. Governor Nuyts went still farther. When they had finished their affairs at Formosa, and were desirous of proceeding, according to their instructions, to China, he put them off with fair words and fine promises till the monsoon was over. They began then to be very impatient, and desired to have their cannon and sails restored, that they might return home; but the governor had recourse to new artifices, and, by a series of false promises, endeavoured to hinder them from making use of the season proper for that voyage.

The Japanese, however, soon perceived his design; and at length, by a bold attempt, accomplished what by fair means and humble entreaty they could not obtain; for, by a daring and well concerted effort, they took him prisoner, and made him and one of the council sign a treaty for securing their liberty, free departure, and indemnity, which was afterwards ratified by the whole council. Nuyts was first confined in Batavia, and afterwards delivered up to the Japanese, notwithstanding the most earnest intreaties on his part to be tried, and even to suffer any kind of death where he was, rather than to be sent to Japan. He was sent there, however, in 1634. He was submitted

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submitted to the mercy or discretion of the emperor; and the consequence was, that, though imprisoned, he was well used, and could go any where, provided his guards were with him, which was more than he could possibly have expected. He now looked for nothing but the continuance of his confinement for life. On a particular occasion, however, *i. e.* at the funeral of the emperor's father, at the request of the Dutch he was set free, and returned again to Batavia, to the surprise of that people, who, however, adopted ever after a very different conduct with respect to the Japanese.

NUZZER, or NUZZERANAH; a present or offering from an inferior to a superior. In Hindostan no man ever approaches his superior for the first time on business without an offering of at least a gold or silver rupee in his right hand; which if not taken, it is a mark of disfavour. Nuzzeranah is also used for the sum paid to the government as an acknowledgement for a grant of lands or any public office.

NYCHTHEMERON, among the ancients, signified the whole natural day, or day and night, consisting of 24 hours, or 24 equal parts. This way of considering the day was particularly adopted by the Jews, and seems to owe its origin to that expression of Moses, in the first chapter of Genesis, "the evening and the morning were the first day."—Before the Jews had introduced the Greek language into their discourse, they used to signify this space of time by the simple expression of a night and a day.

It is proper here to observe, that all the eastern countries reckoned any part of a day of 24 hours for a whole day; and say a thing that was done on the third or seventh day, &c. from that last mentioned, was one after three or seven days. And the Hebrews, having no word which exactly answers to the Greek *Νυχθημερον*, signifying "a natural day of 24 hours," use *night and day*, or *day and night*, for it. So that to say a thing happened after three days and three nights, was, with them, the same as to say it happened after three days, or on the third day. This, being remembered, will explain what is meant by "the Son of Man's being three days and three nights in the heart of the earth."

NYCTALOPIA. See MEDICINE, n° 361.

NYCTANTHES, ARABIAN JASMINE: A genus of the monogynia order, belonging to the diandria class of plants; and in the natural method ranking with the 44th order, *Sapiaria*. The corolla and calyx are octofid; the perianthium dicoccous. There are five species; the most remarkable of which are, 1. The arbor tristis, or sorrowful tree. This tree, or shrub, the *pariatacu* of the Bramins, grows naturally in sandy places in India, particularly in the islands of Ceylon and Java, where it is produced in great abundance, and attains the height of 18 or 20 feet. It rises with a four-cornered stem, bearing leaves that are oval, and taper to a point. They stand opposite, on short foot-stalks; are of a shining brownish-green on the upper side, a more vivid green on the under, and of a taste that is astringent and somewhat bitter. From the middle-rib, on the under surface of the leaves proceed on both sides a number of costulae, or smaller ribs, which run nearly to the margin, and mark the surface with the impression of their arched furrows. The flowers, which are white and highly odoriferous, ha-

N° 244.

ving a sweet delectable smell emulating the best honey, consist of one peral deeply divided into eight parts, which are narrower towards the stalk, and dilated towards the summit. They stand upon foot-stalks, which emerge from the origin of the leaves; are rigid, obliquely raised towards the top, grow opposite in pairs, and are divided into three short lesser branches, which each supports five flowers placed close together, without partial foot-stalks. The fruit is dry, capsular, membranaceous, and compressed.

It is generally asserted of this plant, that the flowers open in the evening, and fall off the succeeding day. Fabricius and Paludanus, however, restrict the assertion, by affirming, from actual observation, that this effect is found to take place only in such flowers as are immediately under the influence of the solar rays. Grimmerius remarks in his *Laboratorium Ceylonicum*, that the flowers of this tree afford a fragrant water, which is cordial, refreshing, and frequently employed with success in inflammations of the eyes. The tube of the flower, when dried, has the smell of saffron; and, being pounded and mixed with sanders-wood, is used by the natives of the Malabar coast for imparting a grateful fragrant to their bodies, which they rub or anoint with the mixture.

2. The sambac, noted, like the other species, for the fragrant of its flowers, is a native likewise of India; and is cultivated in our stoves, where it generally rises with a twining stem to the height of 18 or 20 feet. The leaves are opposite, simple, and entire; but in different parts of the plant assume different forms: the lower leaves being heart-shaped and blunt; the upper, oval and sharp. The flowers are white, inexpressibly fragrant, and generally appear with us in the warm summer-months. Strong loam is its proper soil. There is a variety of this species with a double flower, which is much larger and more fragrant than the former.

NYCTASTRATEGI, among the ancients, were officers appointed to prevent fires in the night, or to give alarm and call assistance when a fire broke out. At Rome they had the command of the watch, and were called *nocturni triumviri*, from their office and number.

NYCTICORAX, in ornithology, the night-raven; a species of ARDEA.

NYE (Philip), an English nonconformist, a native of Sussex, descended of a genteel family there, was born about 1596. After a proper foundation at the grammar-school, he was sent to Oxford, and entered a commoner of Brazen-Nose college in 1615, whence he removed in a little time to Magdalen-hall, under a puritanical tutor. He took the degrees in arts in 1619 and 1622, about which time he entered into holy orders, and was, some time in 1620, curate of St Michael's church in Cornhill, London. Resolving, however, to reject the constitution of the church of England, he became obnoxious to all the censures of the episcopal court; to avoid which he went, with others of his persuasion, to Holland, in 1633. He continued for the most part at Arnheim, in Guelderland, till 1640; when, the power of the parliament beginning to prevail over the king, he returned home, and was soon after made minister of Kimbolton in Huntingdonshire, by Edward Lord Kimbolton, then earl of Manchester. In 1643, he was appointed one of the assembly

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Nye. assembly of divines, and became a great champion of the Presbyterians, and a zealous assertor of the solemn league and covenant; and, having married the daughter of Stephen Marshall, was sent with his father-in-law into Scotland the same year, to expedite the taking of their covenant. Accordingly, he harangued that people, in some speeches on the occasion; in which he told them, among other things, that they were entered into such a covenant and league as would never be forgotten by them and their posterity, and both would have occasion to remember it with joy; that it was such an oath, for matter, persons, and other circumstances, that the like had not been in any age, sufficiently warranted both by human and divine story: for, as God did swear for the salvation of men and kingdoms, so kingdoms must now swear for the preservation and salvation of kingdoms, to establish a Saviour Jesus Christ in England, &c. After his return, both houses of parliament took the covenant the same year; at which time he preached a sermon in defence of it, showing its warrant from scripture, and was rewarded for his good service with the rectory of Acton near London, in the room of Dr Daniel Featley, who was ejected from it. Not long after, however, Nye began to dislike the proceedings of the said assembly of divines, and dissented from them, opposing the discipline intended to be settled by them; and, closing with the Independents when they became the reigning faction, he paid his court to the grandees of the army, who often made use of his counsel. In December 1647 he was sent by them, with Stephen Marshall, to the king at Carisbrook-castle, in the isle of Wight, in attendance upon the commissioners then appointed to carry the four dethroning votes, as they are now called, viz. 1. To acknowledge the war raised against him to be just; 2. To abolish episcopacy; 3. To settle the power of the militia in persons nominated by the two houses; 4. To sacrifice all those that had adhered to him; for which service they were rewarded with no less than 500 l. a piece. Nye was also employed about that time by the same masters to get subscriptions from the apprentices in London, &c. against a personal treaty with the king, while the citizens of that metropolis were petitioning for one. April the next year, he was employed, as well as Marshall and Joseph Caryl, by the Independents, to invite the secured and secluded members to sit in the house again, but without success. In 1653 he was appointed one of the triers for the approbation of public preachers; in which office he not only procured his son to be clerk, but, with the assistance of his father-in-law, obtained for himself a living of 400 l. a-year. In 1654, he was joined with Dr Lazarus Seaman, Samuel Clark, Richard Vines, Obadiah Sedgwick, Joseph Caryl, &c. as an assistant to the commissioners appointed by parliament to eject such as were then called scandalous and ignorant ministers and schoolmasters in the city of London. After Charles II's restoration in 1660, it was debated by the healing parliament, for several hours together, whether he and John Goodwin should be excepted for life; but the result was, that if Philip Nye, clerk, should after the 1st of September, in the same year 1660, accept or exercise any office, ecclesiastical, civil, or military, he should, to all intents and purposes in law, stand as if he had been totally excepted for

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life. November 1662 he was vehemently suspected to be engaged in Tongue's plot; but the suspicion was never proved. He died in the parish of St Michael's, Cornhill, London, in Sept. 27. 1672, and was buried in the upper vault of the said church. Wood says he was a dangerous and seditious person, a politic pulpit-driver of independency, an insatiable esurient after riches, and what not, to raise a family, and to heap up wealth.

NYLAND, a province of Finland in Sweden, lying on the gulf of Finland, to the west of the province of Carelia.

NYL-GHAU, in zoology, of the genus *Bos*, a native of the interior parts of India. "It seems (says Bewick in his Hist. of Quadr.) to be of a middle nature between the cow and the deer, and carries the appearance of both in its form. In size, it is as much smaller than the one, as it is larger than the other: its body, horns, and tail, are not unlike those of a bull; and the head, neck, and legs, are similar to those of a deer. The colour in general is ash or grey, from a mixture of black hairs and white: all along the ridge or edge of the neck, the hair is blacker, longer, and more erect, making a short, thin, and upright mane, reaching down to the hump. Its horns are seven inches long, six inches round at the root, tapering by degrees, and terminating in a blunt point: the ears are large and beautiful, seven inches in length, and spread to a considerable breadth; they are white on the edge and on the inside, except where two black bands mark the hollow of the ear with a zebra-like variety. The height of this animal at the shoulder is four feet one inch; behind the loins, it only measures four feet.

"The female differs considerably from the male both in height and thickness, being much smaller; in shape and colour, very much resembling a deer; and has no horns. She has four nipples, and is supposed to go nine months with young: She commonly has one at a birth, but sometimes two.

"Several of this species were brought to this country in the year 1767, which continued to breed annually for some years after. Dr Hunter, who had one of them in his custody for some time, describes it as a harmless and gentle animal; that it seemed pleased with every kind of familiarity, always licked the hand that either stroaked or fed it, and never once attempted to use its horns offensively. It seemed to have much dependence on its organs of smell, and snuffed keenly whenever any person came in sight: It did so likewise when food or drink was brought to it; and would not taste the bread which was offered, if the hand that presented it happened to smell of turpentine.

"Its manner of fighting is remarkable, and is described thus. Two of the males at Lord Clive's, being put into an inclosure, were observed, while they were at some distance from each other, to prepare for the attack, by falling down upon their knees; they then shuffled towards each other, keeping still upon their knees; and at the distance of a few yards they made a spring, and darted against each other with great force.

"The following anecdote will serve to show, that during the rutting season these animals are fierce and vicious, and not to be depended upon. A labouring man, without knowing that the animal was near him, went up to the outside of the inclosure; the nyl-ghau, with

Nyland,
Nyl-ghau.

Plate
CCCXLVII.

Nymph. the quickness of lightning, darted against the wood-work with such violence, that he broke it to pieces, and broke off one of his horns close to the root. The death of the animal, which happened soon after, was supposed to be owing to the injury he sustained by the blow.

"Bernier says, that it is the favourite amusement of the Mogul emperor to hunt the Nyl-ghau; and that he kills them in great numbers, and distributes quarters of them to his omrahs; which shows that they are esteemed good and delicious food.

"The Nyl-ghau is frequently brought from the interior parts of Asia, as a rare and valuable present to the nabobs and other great men at our settlements in India

"It remains to be considered, whether this rare animal might not be propagated with success in this country. That it will breed here is evident from experience; and if it should prove docile enough to be easily trained to labour, its great swiftness and considerable strength might be applied to the most valuable purposes."

NYMPH, in mythology, an appellation given to certain inferior goddesses, inhabiting the mountains, woods, waters, &c. said to be the daughters of Oceanus and Tethys. All the universe was represented as full of these nymphs, who are distinguished into several ranks or classes. The general division of them is into celestial and terrestrial; the former of which were called *uraniæ*, and were supposed to be intelligences that governed the heavenly bodies or spheres. The terrestrial nymphs, called *epigeiæ*, presided over the several parts of the inferior world; and were divided into those of the water and those of the earth. The nymphs of the water were the *oceanitides*, or nymphs of the ocean; the *nercids*, the nymphs of the sea; the *naiads* and *ephydriades*, the nymphs of the fountains; and the *limniades*, the nymphs of the lakes. The nymphs of the earth were the *oreades*, or nymphs of the mountains; the *napææ*, nymphs of the meadows; and the *dryads* and *hamadryads*, who were nymphs of the forests and groves. Besides these, we meet with nymphs who took their names from particular countries, rivers, &c. as the *cithæroniades*, so called from mount Cithæron in Bœotia: the *dodonides*, from Dodona; *tiberiades*, from the Tiber, &c.—Goats were sometimes sacrificed to the nymphs; but their constant offerings were milk, oil, honey, and wine.

We have the following account of nymphs in Chandler's Greece. "They were supposed to enjoy longevity, but not to be immortal. They were believed to delight in springs and fountains. They are described as sleepless, and as dreaded by the country people. They were susceptible of passion. The Argonauts, it is related, landing on the shore of the Propontis to dine in their way to Colchos, sent Hylas, a boy, for water, who discovered a lonely fountain, in which the nymphs Eunice, Malis, and Nycheia were preparing to dance; and these seeing him were enamoured, and, seizing him by the hand as he was filling his vase, pulled him in. The deities, their copartners in the cave, are such as presided with them over rural and pastoral affairs.

"The old Athenians were ever ready to cry out, A god! or a goddess! The tyrant Pisistratus entered the city in a chariot with a tall woman dressed in armour to resemble Minerva, and regained the Acropolis,

which he had been forced to abandon, by this stratagem; the people worshipping, and believing her to be the deity whom she represented. The nymphs, it was the popular persuasion, occasionally appeared; and nympholepsy is characterized as a frenzy, which arose from having beheld them. Superstition disposed the mind to adopt delusion for reality, and gave to a fancied vision the efficacy of full conviction. The foundation was perhaps no more than an indirect, partial, or obscure view of some harmless girl, which had approached the fountain on a like errand with Hylas, or was retiring after she had filled her earthen pitcher.

"Among the sacred caves on record, one on mount Ida in Crete was the property of Jupiter, and one by Lebadea in Bœotia of Trophonius. Both these were oracular, and the latter bore some resemblance to that we have described. It was formed by art, and the mouth surrounded with a wall. The descent to the landing-place was by a light and narrow ladder, occasionally applied and removed. It was situated on a mountain above a grove; and they related, that a swarm of bees conducted the person by whom it was first discovered. But the common owners of caves were the nymphs, and these were sometimes local. On Cithæron in Bœotia, many of the inhabitants were possessed by nymphs called *Spbragitides*, whose cave, once also oracular, was on a summit of the mountain. Their dwellings had generally a well or spring of water; the former often a collection of moisture condensed or exuding from the roof and sides; and this, in many instances, being pregnant with stony particles, concreted, and marked its passage by incrustation, the groundwork in all ages and countries of idle tales framed or adopted by superstitious and credulous people.

"A cave in Paphlagonia was sacred to the nymphs who inhabited the mountains about Heraclea. It was long and wide, and pervaded by cold water, clear as crystal. There also were seen bowls of stone, and nymphs and their webs and distaffs, and curious work, exciting admiration. The poet who has described this grotto, deserves not to be regarded, as servilely copying Homer; he may justly claim to rank as an original topographer.

"The piety of Archidamus furnished a retreat for the nymphs, where they might find shelter and provision, if distressed; whether the sun parched up their trees, or Jupiter enthroned in clouds upon the mountain-top scared them with his red lightning and terrible thunder, pouring down a deluge of rain, or brightening the summits with his snow."

NYMPH, among naturalists, that state of winged-insects between their living in the form of a worm and their appearing in the winged or most perfect state.

The eggs of insects are first hatched into a kind of worms or maggots; which afterwards pass into the nymph-state, surrounded with shells or cases of their own skins: so that, in reality, these nymphs are only the embryo insects, wrapped up in this covering; from whence they at last get loose, though not without great difficulty.

During this nymph-state the creature loses its motion. Swammerdam calls it *nympha aurelia*, or simply *aurelia*; and others give it the name of *chrysalis*, a term of the like import. See the article **CHRYSA LIS**.

NYMPH-Bank, situated about 10 leagues off the coast of the county of Waterford, and province of Munster

in

Nymphæa, in Ireland, is a great fishing place, and 11 leagues S. S. E. from the high head of Dungarvan. It abounds with cod, ling, skate, bream, whiting, and other fish; which was discovered by Mr Doyle, who on July 15. 1736 sailed to it, in company with seven men, on board the *Nymph*, a small vessel of about 12 guns. This place is well adapted for a fishing company, the great public advantages of which must be very evident.

NYMPHÆ, in anatomy, two membranaceous parts, situated on each side the rima. They are of a red colour, and cavernous structure, somewhat resembling the wattles under a cock's throat. They are sometimes smaller, sometimes larger; and are contiguous to the præputium of the clitoris, and joined to the interior side of the labia.

NYMPHÆA, the WATER-LILY; a genus of the monogynia order, belonging to the polyandria class of plants; and in the natural method ranking under the 54th order, *Miscellaneæ*. The corolla is polypetalous; the calyx tetraphyllous or pentaphyllous; the berry multilocular and truncated. There are four species; of which the most remarkable are, 1, 2. The lutea and alba, or yellow and white water-lilies; both of which are natives of Britain, growing in lakes and ditches. Linnæus tells us, that swine are fond of the leaves and roots of the former; and that the smoke of it will drive away crickets and blattæ, or cockroaches, out of houses.—The root of the second has an astringent and bitter taste, like those of most aquatic plants that run deep into the mud. The Highlanders make a dye with it of a dark chestnut colour. 3. The lotus, with heart-shaped toothed leaves, a plant thought to be peculiar to Egypt, is thus mentioned by Herodotus†: “When the river Nile is become full, and all the grounds round it are a perfect sea, there grows a vast quantity of lilies, which the Egyptians call *lotus*, in the water. After they have cut them, they dry them in the sun; then, having parched the seed within the lotus, which is most like the poppy, they make bread of it, baking it with fire. The root also of the lotus is eatable, easily becoming sweet, being round, and of the size of an apple.” M. Savary‡ mentions it as growing in the rivulets and on the sides of the lakes; and that there are two sorts or varieties of the plant, the one with a white, the other with a bluish flower. “The calyx (he says) blows like a large tulip, and diffuses a sweet smell, resembling that of the lily. The first species produces a round root like that of a potato; and the inhabitants of the banks of the lake Menzall feed upon it. The rivulets in the environs of Damietta are covered with this majestic flower, which rises upwards of two feet above the water. 4. In the East and West Indies grows a species of this plant, named *nelumbo* by the inhabitants of Ceylon. The leaves which rest upon the surface of the water are smooth, undivided, perfectly round, thick, target-shaped, and about one foot and a half in diameter. The footstalk of the leaves is prickly; and inserted, not into their base, or margin, as in most plants, but in the centre of the lower disk or surface. From this centre, upon the upper surface, issue, like rays, a great number of large ribs, or nerves, which towards the circumference are divided and subdivided into a small number of very

† *Euterpe*,
c. 92.

‡ *Letters*
on *Egypt*,
vol. i.

minute parts. The flowers are large, flesh-coloured, and consist of numerous petals, disposed, as in the other species of water-lily, in two or more rows. The seed-vessel is shaped like a top, being broad and circular above, narrow and almost pointed below. It is divided into several distinct cells, which form so many large round holes upon the surface of the fruit; each containing a single seed.—With the flower of this plant, which is sacred among the heathens, they adorn the altars of their temples: they paint their gods sitting upon it; and make use of such pictures to animate the minds of the pious on their death-bed, and to raise their affections to heaven. The stalks, which are used as a pot-herb, are of a wonderful length. The root is very long, extends itself transversely, is of the thickness of a man's arm, jointed and fibrous, with long intervals betwixt the joints. The fibres surround the joints in verticilli or whirls. 5. A species of *nymphæa*, called by the Chinese *lien-hoa* and *nerufar*, is highly extolled in that country for its excellent virtues, and ranked by their physicians among these plants which are employed in the composition of the liquor of immortality. The seeds are there eaten as we eat filberds in Europe: they are more delicate when they are green, but harder of digestion; they are preserved in many different ways with sugar. The root of this plant is also admitted by the Chinese to their tables: in whatever manner it be prepared, it is equally wholesome. Great quantities of it are pickled with salt and vinegar, which they reserve to eat with their rice. When reduced to powder, it makes excellent soup with water and milk. The leaves of the *nerufar* are much used for wrapping up fruits, fish, salt provisions, &c. When dry, the Chinese mix them with their smoking tobacco, to render it softer and milder.

The high veneration in which the *nymphæa lotos* was held by the Egyptians, is fully known; and at this hour it is equally venerated by the Hindoos. Sir William Jones, in speaking of Brimha, Vishnou, and Shiva, as emblematical representations of the Deity, says,

“The first operations of these three powers are evidently described in the different Pouranas by a number of allegories; and from them we may deduce the Ionian philosophy of primæval water, the doctrine of the mundane egg, and the veneration paid to the *nymphæa* or *lotos*, which was anciently revered in Egypt, as it is at present in Hindostan, Tibet, and Nepal. The Tibetians are said to embellish their temples and altars with it; and a native of Nepal made prostrations before it on entering my study where the fine plant and beautiful flowers lay for examination.”

NYMPHÆA (amongst the ancients), doubtful what structures they were; some take them to have been grottos, deriving their name from the statues of the nymphs with which they were adorned; but that they were considerable works appears from their being executed by the emperors Ammian, Victor, Capitolinus; or by the city prefects. In an inscription, the term is written *nymfium*. None of all these *nymphæa* has lasted down to our time. Some years since, indeed, a square building of marble was discovered between Naples and Vesuvius, with only one entrance, and some steps that went down to it. On the right hand as

Nymphæ-
um,
Nymphi-
dius

you enter, towards the head, there is a fountain of the purest water; along which, by way of guard as it were, is laid a naked Arethusa of the whitest marble; the bottom or ground is of variegated marble, and encompassed with a canal fed by the water from the fountain: the walls are set round with shells and pebbles of various colours; by the setting of which, as by so many strokes in a picture, are expressed the 12 months of the year, and the four political virtues; also the rape of Proserpine; Pan playing on his reed, and soothing his flock; besides the representations of nymphs swimming, sailing, and wantoning on fishes, &c.

It seems pretty evident that the nymphæa were public baths; for at the same time that they were furnished with pleasing grottoes, they were also supplied with cooling streams, by which they were rendered exceedingly delightful, and drew great numbers of people to frequent them. Silence seems to have been a particular requisite there, as appears by this inscription, *Nymphis loci, bibe, lava, tace*. That building between Naples and Vesuvius mentioned above, was certainly one of these nymphæa.

NYMPHÆUM, (Plutarch); the name of a sacred place, near Apollonia in Illyricum, sending forth continually fire in detached streams from a green valley and verdant meadows. Dio Cassius adds, that the fire neither burns up nor parches the earth, but that herbs and trees grow and thrive near it, and therefore the place is called *nymphæum*: near which was an oracle of such a nature, that the fire, to show that the wish was granted, consumed the frankincense thrown into it; but repelled it, in case the desire was rejected. It was there that a sleeping satyr was once caught and brought to Sylla as he returned from the Mithridatic war. This monster had the same features as the poets ascribe to the satyr. He was interrogated by Sylla and by his interpreters; but his articulations were unintelligible, and the Roman spurned from him a creature which seemed to partake of the nature of a beast more than that of a man.

NYMPHEUM, in antiquity, a public hall magnificently decorated, for entertainment, &c. and where those who wanted convenience at home held their marriage-feasts; whence the name.

NYMPHIDIUS (Sabinus), a person of mean descent, but appointed by Nero colleague of Tigellinus in the command of the prætorian guards. About the time, however, that the German legions revolted from this despicable prince, he was also betrayed by Nymphidius and abandoned by his guards.

Nymphidius began now to entertain thoughts of seizing the sovereignty himself. However, he did not immediately declare his ambitious views; but pretending to espouse the cause of Galba, assured the guards that Nero was fled, and promised them such sums as neither Galba nor any other was able to discharge. This promise secured for the present the empire to Galba, occasioned afterwards the loss of it, and, finally, produced the destruction of Nymphidius and the guards themselves. After Nero's death, however, and on the acknowledgment of Galba as emperor, he renewed his ambition; and having, by his immense largesses, gained the affections of the prætorian guards, and persuading himself that Galba, by

reason of his infirmities and old age, would never reach the capital, usurped all the authority at Rome. Presuming upon his interest, he obliged Tigellinus, who commanded, jointly with him, the prætorian guards, to resign his commission. He made several magnificent and expensive entertainments, inviting such as had been consuls or had commanded armies, distributed large sums among the people, and with shows and other diversions, which he daily exhibited, gained so great an interest with all ranks, that he already looked upon himself as sovereign. The senate, dreading his power, conferred extraordinary honours upon him, styled him their *Protector*, attended him when he appeared in public, and had recourse to him for the confirmation of their decrees, as if he had been already invested with the sovereign power. This base compliance elated him to such a degree, that he usurped, not leisurely and by degrees, but all at once, an absolute authority. He acted as sovereign indeed, but he had not as yet openly declared his design of seizing the empire: his power, however, was great, and he used it in undermining Galba's power; he was, however, unsuccessful, and the disclosure of his designs was much against him. Galba was again acknowledged and proclaimed, and he, notwithstanding his artifices, detected and slain by the soldiers who were proclaiming Galba. See NERO.

NYON, a considerable town of Switzerland, in the canton of Bern, and capital of a bailiwick of the same name, with a castle. It stands delightfully upon the edge of the lake of Geneva, in the very point where it begins to widen, and in a most charming country commonly called *Pays de Vand*. It was formerly called *Colonia Equestris Noiodunum*; and, as a proof of its antiquity, several Roman inscriptions, and other ancient remains, have been frequently discovered in the outskirts of the town. E. Long. 5. 10. N. Lat. 46. 24.

NYSA, or NYSSA (anc. geog.), a town of Ethiopia, at the south of Egypt. Some place it in Arabia. This city, with another of the same name in India, was sacred to the god Bacchus, who was educated there by the nymphs of the place, and who received the name of *Dionysus*, which seems to be compounded of *Διός* and *Νύσα*, the name of his father, and that of the place of his education. The god made this place the seat of his empire, and the capital of the conquered nations of the east. According to some geographers, there were no less than ten places of this name. One of these was famous on the coast of Eubœa for its vines, which grew in such an uncommon manner, that if a twig was planted in the ground in the morning, it immediately produced grapes which were full ripe in the evening. A city of Thrace: another seated on the top of Mount Parnassus, and sacred to Bacchus.

NYSLÖT, a strong town of Russia, in Livonia, with a castle; seated on the river Narva, among large marshes. E. Long. 26. 55. N. Lat. 58. 46.

NYSSA, in botany: A genus of the order of diœcia, belonging to the polygamia class of plants; and in the natural method ranking under the 12th order, *Holoracea*. The hermaphrodite calyx is quinquepartite; there is no corolla; the stamina are five; there is one pistil; the fruit a plum inferior. The male calyx is quinquepartite, no corolla, and ten sta-

mina,

Nyon
||
Nyssa.

Nyssa.

mina. There is only one species, the *nyssa aquatica* or tupelo tree. It is a deciduous tree or shrub, a native of moist or watery places in America, and consists of two varieties; 1. The entire-leaved; and, 2. The serrated-leaved tupelo.

Planting
and Gar-
dening.

The entire-leaved tupelo tree, in its native soil and climate, grows to near 20 feet high; in this country its size varies according to the nature of the soil or situation. In a moist rich earth, well sheltered, it comes near to 20 feet; in others, that are less so, it makes slower progress, and in the end is proportionally lower. The branches are not very numerous; and it rises with a regular trunk, at the top of which they generally grow. The leaves are of a lanceolated figure, and of a fine light-green colour. They end in acute points, and are very ornamental, of a thickish consistence, soft, grow alternately on pretty long footstalks, and often retain their verdure late in the autumn. The flowers, which are not very ornamental, are produced from the sides of the branches, growing sometimes singly, sometimes many together, on a footstalk. They are of a greenish colour; and, in the countries where they naturally grow, are succeeded by oval drupes, inclosing oval, acute, furrowed nuts. In England they seldom produce fruit.

The serrated-leaved tupelo tree grows usually nearly 30 feet in height; and divides into branches near the top like the other. The leaves are oblong, pointed, of a light-green colour, and come out without order on long footstalks. The flowers come out from the wings of the leaves on long footstalks. They are small, of a greenish-colour; and are succeeded by oval drupes, containing sharp-pointed nuts, about the size of a French olive.

The propagation of these trees is from seeds, which come from America. As soon as they arrive, they should be sown in large pots of light sandy earth an

inch deep. The gardener (no plants come up the first spring), after this work is done, should plunge his pots up to their rims in the natural ground; and if it be a moist place, it will be the better. Weeding must be observed during the summer; and a few furze-bushes should be pricked round the pots in November, which will prevent the ground from freezing, and forward the coming up of the seeds. In the next spring, the pots should be plunged into an hot-bed, and after that the seeds will soon appear. As much air as possible, and watering, should be afforded them; and they must be hardened soon, to be set out. The pots should then be plunged to their rims again in the natural mould; where they are to remain till October. Watering must be given them; and they should also be shaded in the heat of the day. In October, they must be housed, with other greenhouse plants, or else set under a hot-bed-frame, or some other cover, during winter. The third spring they should be taken out of the larger pots, and each planted in a smaller, in which their growth may be assisted by a gentle heat in a bed; but if they are planted up to the rims in a moist place, and shaded in dry weather, they will grow very well. Though by this time they should have become hardy, yet it will be proper to shelter them the winter following in bad weather. They will require little more care during their stay in the pots, which may be either two, three, or more years, if they are large enough; when in spring they may be turned out, with the mould, into the places where they are to remain, which ought always to be moist and properly sheltered.

Nyssa,
Nyu.che.

NYU-CHE, or KIN, an empire which arose in eastern Tartary in the beginning of the 13th century. From the founder of this empire the late Chinese emperor Kang-hi said that his family was descended. See CHINA and TARTARY.

O.

O, The 14th letter and fourth vowel of our alphabet; pronounced as in the words *nose, rose*, &c.

The sound of this letter is often so soft as to require it double, and that chiefly in the middle of words; as *goose, reproof*, &c. And in some words this *oo* is pronounced like *u* short, as in *flood, blood*, &c.

As a numeral, *O* was sometimes used for *11* among the ancients; and with a dash over it thus, *Ō*, for *11,000*.

In the notes of the ancients, *O. CON.* is read *opus conductum*; *O. C. Q.* *opera consilioque*; *O. D. M.* *opera, donum munus*; and *O. LO.* *opus locatum*.

The Greeks had two *O*'s; viz. omicron, *o*, and omega, *ω*; the first pronounced on the tip of the lips with a sharper sound; the second in the middle of the mouth, with a fuller sound, equal to *oo* in our language. The long and short pronunciation of our *O*

are equivalent to the two Greek ones; the first, as in *suppose*; the second, as in *obey*.

O is usually denoted long by a servile *a* subjoined, as *moan*; or by *e* at the end of the syllable, as *bone*; when these vowels are not used, it is generally short.

Among the Irish, the letter *O*, at the beginning of the name of a family, is a character of dignity annexed to great houses. Thus, in the history of Ireland, we frequently meet with the *O Neals, O Carrols*, &c. considerable houses in that island.

Cambden observes, that it is the custom of the lords of Ireland to prefix an *O* to their names to distinguish them from the commonalty.

The ancients used *O* as a mark of triple time; from a notion that the ternary, or number 3, was the most perfect of numbers, and therefore properly expressed by a circle, the most perfect of figures.

It is not, strictly speaking, the letter *O*, but the figure.

O.
Oak.

figure of a circle $\bigcirc$, or double $\bigcirc$, by which the modern ancients in music used to express what they called *tempo perfetto*, or triple time. Hence the Italians call it *circolo*.

The seven antiphones, or alternate hymns of seven verses, &c. sung by the choir in the time of Advent, were formerly called *O*, from their beginning with such an exclamation.

O is an adverb of calling, or interjection of sorrow or wishing.

OAK, in botany. See *QUERCUS*.

The oak has been long known by the title of *monarch of the woods*, and very justly. It was well known, and often very elegantly described, by the ancient poets. The following description from Virgil is exquisite :

*Veluti annojo validam cum robore quercum
Alpini Boreæ, nunc hinc, nunc flatibus illinc
Eruere inter se certant : it stridor, et alte
Consternunt terram concusso stipite frondes :
Ipsa hæret scopulis ; et quantum vertice ad auras
Ætherias, tantum radice in Tartara tendit.*

ÆN. iv. 441.

As o'er th' aerial Alps sublimely spread,
Some aged oak uprears his reverend head ;
This way and that the furious tempests blow,
To lay the monarch of the mountains low ;
Th' imperial plant, though nodding at the sound,
Though all his scatter'd honours strow the ground ;
Safe in his strength, and seated on the rock,
In naked majesty defies the shock :
High as the head shoots tow'ring to the skies,
So deep the root in hell's foundation lies.

PITT.

* *Nat. Hist.*
xvi. c. 44.

The ancient druids had a most profound veneration for oak trees. Pliny * says, that "the druids (as the Gauls call their magicians or wise men) held nothing so sacred as the mistletoe, and the tree on which it grows, provided it be an oak. They make choice of oak groves in preference to all others, and perform no rites without oak-leaves ; so that they seem to have the name of druids from thence, if we derive their name from the Greek," &c. (See *DRUIDS*—definition, and no 11.) Maximus Tyrius says the Celtæ or Gauls worshipped Jupiter under the figure of a lofty oak (A).

This useful tree grows to such a surprising magnitude, that were there not many well authenticated instances of them in our own country, they would certainly appear difficult of belief. In the 18th volume of the Gentleman's Magazine we have the dimensions of a leaf twelve inches in length and seven in breadth, and all the leaves of the same tree were equally large. On the estate of Woodhall, purchased in 1775 by Sir Thomas Rumbold, bart. late governor of Madras, an oak was felled which sold for 43l. and measured 24 feet round. We are also told of one in Millwood fo-

rest, near Chaddeley, which was in full verdure in winter, getting its leaves again after the autumn ones fell off. In Hunter's Evelyn's Sylva, we have an account of a very remarkable oak at Greendale ; which Gough, in his edition of Cambden, thus minutely describes: "The Greendale oak, with a road cut thro' it, still bears one green branch. Such branches as have been cut or broken off are guarded from wet by lead. The diameter of this tree at the top, whence the branches issue, is 14 feet 2 inches ; at the surface of the ground 11½ feet ; circumference there 35 feet ; height of the trunk 53 ; height of the arch 10, width 6. Mr Evelyn mentions several more oaks of extraordinary size in Workshop park."

In the Gentleman's Magazine for 1773 we have an account of one differing very essentially from the common one ; it is frequent about St Thomas in Devonshire, and is in that county called *Lucombe oak*, from one William Lucombe who successfully cultivated it near Exeter. It grows as straight and handsome as a fir ; its leaves are evergreen, and its wood as hard as that of the common oak. Its growth is so quick, as to exceed in 20 or 30 years the altitude and girth of the common one at 100. It is cultivated in various places ; Cornwall, Somersetshire, &c.

M. du Hamel du Monceau, of the Royal Academy of Sciences at Paris (who wrote a treatise on husbandry), gave an account in the year 1749 of an oak which he had kept in water eight years, and which yielded fine leaves every spring. The tree had, he says, four or five branches ; the largest 19 or 20 lines round, and more than 18 inches long. It throve more in the two first years than it would have done in the best earth ; it afterwards lost its vigour, and rather decayed ; which he attributed to a defect in the roots rather than to want of aliment.

M. de Buffon made some experiments on oak-trees ; the result of which is recorded in the Gentleman's Magazine, 1754. He had compared barked with unbarked trees ; and proves, we think with success, from a variety of trials, that timber barked and dried standing, is always heavier and considerably stronger than timber kept in its bark.

The bark of oak-trees was formerly thought to be extremely useful in vegetation. One load (Mr Mills in his treatise on husbandry informs us) of oak-bark, laid in a heap and rotted, after the tanners have used it for dressing of leather, will do more service to stiff cold land, and its effects will last longer, than two loads of the richest dung ; but this has been strenuously controverted. (See *OAK-LEAVES*.)

The bark, in medicine, is also a strong astringent ; and hence stands recommended in hæmorrhagies, alvine fluxes, and other preternatural or immoderate secretions ; and in these it is sometimes attended with good effects. Some have alledged, that by the use of this bark every purpose can be answered which may be obtained from Peruvian bark. But after several very fair

Oak.

(A) Cambden informs us of a tradition (which, like most other traditions of this nature, seems to be founded in ignorance and fostered by credulity) respecting an oak near Malwood castle, where Rufus was killed, viz. that it budded on Christmas-day, and withered before night. This tree, the same tradition reports to have been that against which Tyrrel's arrow glanced.

Oak.

Oak.

fair trials, we have by no means found this to be the case. Besides the bark, the buds, the acorns, and their cups are used; as also the galls, which are excrescences caused by insects on the oaks of the eastern countries, of which there are divers sorts; some perfectly round and smooth, some rougher with small protuberances, but all generally having a round hole in them. All the parts of the oak are styptic, binding, and useful in all kinds of fluxes and bleedings, either inward or outward. The bark is frequently used in gargarisms, for the relaxation of the uvula, and for sore mouths and throats: it is also used in restraining clysters and injections, against the prolapsus uteri or ani. The acorns, beaten to powder, are frequently taken by the vulgar for pains in the side. The only officinal preparation is the aqua germinum quercus.

OAK-LEAVES. The uses of oak-bark in tanning, and in hot-beds, is generally known. For the latter of these purposes, however, oak-leaves are now found to answer equally well, or rather better. In the notes to Dr Hunter's edition of Evelyn's Treatise on Forestry, we find the following directions for their use by W. Speechly: The leaves are to be raked up as soon as possible after they fall from the trees. When raked into heaps, they should immediately be carried into some place near the hot-houses, where they may lie to couch. Mr Speechly says, it was his custom to fence them round with charcoal hurdles, or any thing else, to keep them from being blown about the garden in windy weather. In this place they tread them well, and water them in case they happen to have been brought in dry. The heap is made six or seven feet thick, and covered over with old mats, or any thing else, to prevent the upper leaves from being blown away. In a few days the heap will come to a strong heat. For the first year or two in which he used these leaves, our author did not continue them in the heap longer than ten days or a fortnight: but by this method of management they settled so much when brought to the hot-house, that a supply was very soon required; and he afterwards found, that it was proper to let them remain five or six weeks in the heaps before they are brought to the hot-house. In getting them into the pine-pots, if they appear dry, they are to be watered, and again trodden down exceedingly well, in layers, till the pits are quite full. The whole is then covered with tan-bark, to the thickness of two inches, and well trodden down, till the surface becomes smooth and even. On this the pine-pots are to be placed in the manner they are to stand, beginning with the middle row first, and filling up the spaces between the pots with tan. In this manner we are to proceed to the next row, till the whole be finished; and this operation is performed in the same manner as when tan only is used. The leaves require no farther trouble through the whole season; as they will retain a constant and regular heat for 12 months without stirring or turning; and our author informs us, that if he may judge from their appearance when taken out (being always entire and perfect), it is probable they would continue their heat through a second year; but, as an annual supply of leaves is easily obtained, the experiment is hardly worth making. After this, the pines will have no occasion to be moved, but at stated times

of their management, viz. at the shifting them in their pots, &c. when at each time a little fresh tan should be added to make up the deficiency arising from the settling of the beds; but this will be inconsiderable, as the leaves do not settle much after their long couching. During the first two years of our author's practice he did not use any tan, but plunged the pine-pots into the leaves, and just covered the surface of the beds, when finished, with a little saw-dust, to give it a neatness. This method, however, was attended with one inconvenience; for by the caking of the leaves they shrunk from the sides of the pots, whereby they became exposed to the air, and at the same time the heat of the beds was permitted to escape.

"Many powerful reasons (says Mr Speechly) may be given why oak-leaves are preferable to tanner's bark.

"1. They always heat regularly; for during the whole time that I have used them, which is near seven years, I never once knew of their heating with violence; and this is so frequently the case with tan, that I affirm, and indeed it is well known to every person conversant in the management of the hot-house, that pines suffer more from this one circumstance, than all the other accidents put together, insects excepted. When this accident happens near the time of their fruiting, the effect is soon seen in the fruit, which is exceedingly small and ill-shaped. Sometimes there will be little or no fruit at all; therefore gardeners who make use of tan only for their pines, should be most particularly careful to avoid an over-heat at that critical juncture,—the time of showing the fruit.

"2. The heat of oak-leaves is constant; whereas tanner's bark generally turns cold in a very short time after its furious heat is gone off. This obliges the gardener to give it frequent turnings in order to promote its heating. These frequent turnings, not to mention the expence, are attended with the worst consequences; for by the continual moving of the pots backwards and forwards, the pines are exposed to the extremes of heat and cold, whereby their growth is considerably retarded; whereas, when leaves are used, the pines will have no occasion to be moved but at the times of potting, &c. The pines have one peculiar advantage in this undisturbed situation; their roots grow through the bottoms of the pots, and mat among the leaves in a surprising manner. From the vigour of the plants when in this situation, it is highly probable that the leaves, even in this state, afford them an uncommon and agreeable nourishment.

"3. There is a saving in point of expence; which is no inconsiderable object in places where tan cannot be had but from a great distance.

"4. The last ground of preference is, that decayed leaves make good manure; whereas rotten tan is experimentally found to be of no value. I have often tried it both on sand and clay, and on wet and dry land; and never could discover, in any of my experiments, that it deserved the name of a manure; whereas decayed leaves are the richest, and of all others the most proper manure for a garden. Leaves mixed with dung make excellent hot-beds; and I find that beds compounded in this manner, preserve their heat much longer than when made entirely with dung; and in both

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both cases, the application of leaves will be a considerable saving of dung, which is a circumstance on many accounts agreeable."

Oak-Leaf-Galls. These are of several kinds; the remarkable species called the *mushroom gall* is never found on any other vegetable substance but these leaves; and beside this there are a great number of other kinds.

The double gall of these leaves is very singular, because the generality of productions of this kind affect only one side of a leaf or branch, and grow all one way; whereas this kind of gall extends itself both ways, and is seen on each side of the leaf, in form of two protuberances, opposite the one to the other. These are of differently irregular shapes, but their natural figure seems that of two cones, with broad bases, and very obtuse points, though sometimes they are round, or very nearly so.

These make their first appearance on the leaf in April, and remain on it till June or longer. They are at first green, but afterwards yellowish, and are softer to the touch than many other of the productions of this kind: they are usually about the size of a large pea, but sometimes they grow to the bigness of a nut. When opened, they are found to be of that kind which are inhabited each by one insect only, and each contain one cavity. The cavity in this is, however, larger than in any other gall of the size, or even in many others of three times the size; the sides of it being very little thicker than the substance of the leaf.

It is not easy to ascertain the origin of the several species of flies which are at times seen in this manner to come out of the same species of galls. It seems the common course of nature, that only one species of insect forms one kind of gall; yet it may be, that two or three kinds may give origin to the same kind. There is, however, another occasion of our seeing different species come out of different galls of the same kind; and this is the effect of the enemies of the proper inhabitants.

It might appear that the parent fly, when she had formed a gall for the habitation of her worm offspring, had placed it in an impregnable fortress: but this is not the case; for it frequently happens, that a fly, as small perhaps as that which gave origin to the gall, produces a worm which is of the carnivorous kind, as the other feeds on vegetable juices. This little fly, well knowing that where there is one of these protuberances on a leaf, there is a tender and defenceless insect within, pierces the sides of the gall, and deposits her egg within it. This, when it hatches into a worm, feeds upon the proper inhabitant; and finally, after devouring it, passes into the chrysalis state, and thence appears in the form of its parent fly, and is seen making its way out of the gall, in the place of the proper inhabitant.

On opening these leaf-galls, which are properly the habitation only of one animal, it is common to find two, the stronger preying upon the body of the other, and sucking its juices as it does those of the leaf; often it is found wholly employed in devouring its unoffending neighbour at once: this is probably the case when its time of eating is nearly over; and, in fine, when we find the gall inhabited by only one insect, or

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containing only one chrysalis, as it ought in its natural state to do, we are never certain that this is the proper inhabitant, as it may be one of these destroyers who has eaten up the other, and supplied its place. See *APHIS* and *Oak PUCCERON*.

Oak Saw-dust is now found to answer the purposes of tanning as well, at least, as the bark. See *TANNING*.

Oak of Jerusalem. See *CHENOPODIUM*.

OAKHAM, *OCKHAM*, or *Oakum*, in sea-language, denotes the matter of old ropes untwisted and pulled out into loose hemp, in order to be used in caulking the seams, tree-nails, and bends of a ship, for stopping or preventing leaks.

OAKHAMPTON, a town of Devonshire, which sends two members to parliament; situated in W. Long. 4. 5. N. Lat. 50. 48.

OANNES, a being in Chaldean mythology, represented as half a man and half a fish. According to Berosus and other fabulous writers, this monster was the civilizer of the Chaldeans; to whom he taught a system of jurisprudence so perfect as to be incapable of improvement. In discharging the duties of his office, he spent the day on dry land, but retired every night into the ocean or the river. See *MYTHOLOGY*, n° 25.

OAR, a long piece of timber, flat at one end and round or square at the other; and which being applied to the side of a floating vessel, serves to make it advance upon the water.

That part of the oar which is out of the vessel, and which enters into the water, is called the *blade*, or *wash plat*; and that which is within-board is termed the *loom*, whose extremity being small enough to be grasped by the rowers, or persons managing the oars, is called the *handle*.

To push the boat or vessel forwards by means of this instrument, the rowers turn their backs forward, and, dipping the blade of the oar in the water, pull the handle forward so that the blade at the same time may move aft in the water: but since the blade cannot be so moved, without striking the water, this impulsion is the same as if the water were to strike the blade from the stern towards the head: the vessel is therefore necessarily moved according to this direction. Hence it follows, that she will advance with the greater rapidity, by as much as the oar strikes the water more forcibly. Thus it is evident, that an oar acts upon the side of a boat or vessel like a lever of the second class, whose fulcrum is the station upon which the oar rests on the boat's gunnel. In large vessels, this station is usually called the *row-port*; but in lights and boats it is always termed the *row-lock*.

OARISTUS, or *OARISTYS*, a term in the Greek poetry, signifying a dialogue between a husband and his wife; such as that in the sixth book of the *Iliad* between Hector and Andromache.

Scaliger observes, that the oaristus is not properly any particular little poem, or entire piece of poetry; but always a part of a great one. He adds, that the passage now cited in Homer is the only proper oaristus extant in the ancient poets.

OAT, in botany. See *AVENA*.

Under the word *AVENA* it was observed, that the native place of the common oat, cultivated in our fields,

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Oat.

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is unknown; that the only account of it, in its natural state, which we then had, is in Anson's Voyage; and that the report of such an author respecting facts in natural history is not intitled to implicit credit. We had not then seen the Travels of Mr Bruce, whose botanical knowledge is very superior to that of most voyagers, or we should have mentioned his account of the oats which he found growing wild in Aroossi, a small territory in Abyssinia, not far from the source of the Nile: (See NILE). "Wild oats (says he) grow up here spontaneously to a prodigious height and size, capable often of concealing both the horse and his rider, and some of the stalks being little less than an inch in circumference. They have, when ripe, the appearance of small canes. The inhabitants make no sort of use of this grain in any period of its growth: the uppermost thin husk of it is beautifully variegated with a changeable purple colour; the taste is perfectly good. I often made the meal into cakes in remembrance of Scotland." Our author informs us, that the Abyssinians could never be brought to relish these cakes, which they said were bitter, burnt their stomachs, and made them thirsty. He is, however, decidedly of opinion, that the wild oat of Aroossi is the oat in its original state; and that it has degenerated everywhere in Europe. From the facts which he states, this opinion seems to be well founded.

OATH, an affirmation or promise, accompanied with an invocation of God to witness what we say; and with an imprecation of his vengeance, or a renunciation of his favour, if what we affirm be false, or what we promise be not performed (A).

The laws of all civilized states have required the security of an oath for evidence given in a court of justice, and on other occasions of high importance (B); and the Christian religion utterly prohibits swearing, except when oaths are required by legal authority. Indeed no serious and reflecting theist, whether he admit the truth of revelation or not, can look upon swearing on trivial occasions as any thing else than a sin of a very heinous nature. To call upon that in-

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finite and omnipresent Being, who created and sustains the universe, to witness all the impertinence of idle conversation, of which great part is commonly uttered at *random*, betrays a spirit so profane, that nothing short of experience could make us believe it possible for a creature endowed with reason and reflection to be habitually guilty of a practice so impious. No man can plead in extenuation of this crime, that he is tempted to swear by the importunity of any appetite or passion implanted in the human breast: for the utterance of a profane oath communicates no pleasure, and removes no uneasiness; it neither elevates the speaker, nor depresses the hearer.

Quakers and Moravians, swayed by these considerations, and by the sense which they put upon certain texts of Scripture, refuse to swear upon any occasion, even at the requisition of a magistrate, and in a court of justice. These scruples are groundless; and seem to proceed from an incapacity to distinguish between the proper use and abuse of swearing. It is unquestionably impious to call upon God to witness impertinences, or to use his tremendous name as a mere *expletive* in conversation; but it by no means follows, that we may not piously call upon him to witness truths of importance, or invoke his name with reverence and solemnity. No individual could, without gross profaneness, pray for a thousand times more wealth than he may ever have occasion to use; but it was never thought profane to pray "day by day for our daily bread, for rain from heaven, and fruitful seasons." If it be lawful to ask of God these earthly blessings, because he alone can bestow them; it cannot surely be unlawful, where the lives or properties of our neighbours, or the security of government is concerned, to invoke him with reverence to witness the truth of our assertions, or the sincerity of our intentions; because of our truth in many cases, and of our sincerity in all, none but he can be the witness.

The text of Scripture upon which the Quakers chiefly rest their argument for the unlawfulness of all swearing under the Gospel, is our Saviour's prohibition

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(A) The word *oath* is a corruption of the Saxon *eoth*. It is often in England called a *corporal oath*, because, in the days of popery, the person sworn over the host or *corpus Christi*.

(B) The various oaths required by different nations at different times, and the various forms, &c. of imposing them, is a subject of very considerable extent and curiosity: An account of them does not fall within the plan of the present article; it would indeed extend it to an undue length: we cannot, however, omit observing, what is doubtless very remarkable, that the grand impostor Mohammed taught the Moslems, that their oaths might be dissolved. This wonderful doctrine is contained in the 66th chapter of the Koran; which, to free himself from his promise and oath to Hafsa his spouse, he pretended was revealed. What the use of oaths is in such circumstances, or what security they afford for performance, it is difficult to ascertain.

It is also very remarkable, that an oath respecting marriages was the cause of the first divorce at Rome. The circumstance happened about the year of the city 525, Posthumius Albinus and Spurius Carvilius being consuls. The censors of this year observing the population declining, and imagining it proceeded from interested marriages and promiscuous cohabitation, obliged all the citizens to swear, that they would not marry with any other view than that of peopling the republic. It raised, however, many scruples, and occasioned many domestic ruptures. Among the rest, one Carvilius Ruga, a man of distinction, imagined that he was bound by his oath to divorce his wife, whom he passionately loved, because she was barren; which was the first instance of a divorce at Rome from its foundation, though the marriage-laws of the kings allowed it; it afterwards, however, became shamefully frequent. This is also a striking instance of the great attention paid to oaths among the Romans: it is remarked indeed by all writers, that they paid a most profound respect to them; and on that we know they founded their hopes of success in war.

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tion (Mat. v. 34.): "I say unto you, swear not at all." But whoever shall take the trouble of turning over his Bible, and looking at the context, will perceive, that it is only in *ordinary conversation*, and by no means in courts of justice, that our Lord prohibits his followers from swearing at all. There is no evidence whatever, that swearing by *heaven*, by *the earth*, by *Jerusalem*, or by their own *heads*, was the form of a *judicial oath* in use among the Jews. On the contrary, we are told by *Maimonides**, that "if any man swear by heaven or by earth, yet this is not an oath;" which surely he could not have said, had such been the forms of judicial swearing. Indeed they could not have admitted such forms into their courts without expressly violating the law of Moses, who commands them to "Fear the Lord (JEHOVAH) their God, to serve him, and to swear by his NAME." But the Jews, as every one knows, had such a reverence for the name *Jehovah*, that they would not pronounce it on slight occasions, and therefore could not swear by that name in common conversation. Hence, to gratify their propensity to common swearing, they invented such oaths as, by *heaven*, by *earth*, by *Jerusalem*, by *the life of thy head*, &c. and by this contrivance they thought to avoid the guilt of profaning the name JEHOVAH. These, however, being appeals to insensible objects, either had no meaning, or were in fact, as our Saviour justly argues, oaths by that God whose creatures they were; so that the Jew who swore them was still guilty of profaneness towards the very JEHOVAH whose name his superstition would not permit him to pronounce. But what puts it beyond all doubt that the use of judicial oaths is not wholly prohibited in the gospel, is the conduct of our Saviour himself as well as of his apostle St Paul. When Jesus was simply *asked* by the high priest, what it was which certain false witnesses testified against him? we are told by the evangelists, that "he held his peace:" but being *adjured* by the living God to declare whether he was the Christ, the Son of God, or not, he immediately answered the high priest, without objecting to the *oath* (for such it was) upon which he was examined. "St Paul, in his Epistle to the Romans†, says, 'God is my witness, that, without ceasing, I make mention of you in my prayers;' and to the Corinthians, still more strongly, 'I call God for a record upon my soul, that, to spare you, I came not as yet to Corinth.' Both these expressions are of the nature of oaths; and the author of the Epistle to the Hebrews speaks of the custom of swearing judicially without any mark of censure or disapprobation; 'Men verily swear by the greater; and an oath, for confirmation, is to them an end of all strife.'"

* See *White's*
by on the
Place.

† *Paley's*
Moral Phi-
losophy.

But though a nation has an undoubted right to require the security of an oath upon occasions of real importance, we do not hesitate to say, that, in our opinion, it is something worse than bad policy to

multiply oaths, and to hold out to the people temptations to perjure themselves. The security which an oath affords, depends entirely upon the reverence which attaches to it in the mind of him by whom it is given; but that reverence is much weakened by the frequency of oaths, and by the careless manner in which they are too often administered. An excellent moralist‡ observes, with truth, that "the levity and frequency with which oaths are administered, has brought about a general inadvertency to the obligation of them, which both in a religious and political view is much to be lamented: and it merits (continues he) public consideration, whether the requiring of oaths on so many frivolous occasions, especially in the customs, and in the qualification for petty offices, has any other effect than to make them cheap in the minds of the people. A pound of tea cannot travel regularly from the ship to the consumer without costing half a dozen oaths at least; and the same security for the due discharge of his office, namely that of an oath, is required from a *church-warden* and an *archbishop*, from a *petty constable* and the *chief justice* of England. Let the law continue its own sanctions, if they be thought requisite; but let it spare the solemnity of an oath: and where it is necessary, from the want of something better to depend upon, to accept a man's own word or own account, let it annex to prevarication penalties proportioned to the public consequence of the offence."

Mr Paley.

That these pernicious consequences of frequent oaths are not felt only in England, we have the evidence of another respectable writer, whose acuteness well qualified him to observe, whilst his station in society furnished him with the best opportunities of observing, the effects of repeated swearing upon the morals of Scotchmen. "Customhouse-oaths (says Lord Kames*) have become so familiar among us, as to be swallowed without a wry face; and is it certain that bribery and perjury in electing parliament-members are not approaching to the same cool state? Men creep on to vice by degrees. Perjury, in order to support a friend, has become customary of late years; witness fictitious qualifications in the electors of parliament-men, which are made effectual by perjury: yet such is the degeneracy of the present times(c), that no man is the worse thought of upon that account. We must not flatter ourselves, that the poison will reach no farther: a man who boggles not at perjury to serve a friend, will in time become such an adept, as to commit perjury in order to ruin a friend when he becomes an enemy."

* *Sketches of*
the History of
Man.

Besides the frequency of oaths, we have mentioned the irreverent manner in which they are too often administered as one of the causes which make them cheap in the estimation of the people. In this view, the form of the oath, and the ceremonies with which it is required to be taken, are of considerable importance.

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(c) Such was the case when his Lordship wrote. Some decisions of the house of peers, however, have since that period changed mens opinions respecting the legality of these votes and the innocence of the means by which they were made effectual. It is to be hoped that such a reformation will soon be made of the laws by which elections are regulated in Scotland, as will render the temptations to perjury less numerous than they have hitherto been.

Oath. "The forms of oaths in Christian countries (says Mr Paley) are very different; but in none I believe worse contrived either to convey the meaning or to impress the obligation of an oath, than in England. In that country the juror, after repeating the promise or affirmation which the oath is intended to confirm, adds, 'so help me God;' or more frequently the substance of the oath is repeated to the juror by the officer or magistrate who administers it; adding in the conclusion, 'so help you God.' The energy of the sentence resides in the particle *so*; *so*, i. e. *hac lege*, 'upon condition of my speaking the truth, or performing this promise, may God help me, and not otherwise.' The juror, whilst he hears or repeats the words of the oath, holds his right hand upon a Bible, or other book containing the four gospels. The conclusion of the oath sometimes runs, '*ita me Deus adjuvet, et hæc sancta evangelia*,' or 'so help me God, and the contents of this book;' which last clause forms a connection between the words and action of the juror, which before was wanting. The juror then kisses the book."

This obscure and elliptical form, the excellent author justly observes, is ill calculated to impress the juror with reverence: and he seems to think great preference due to the form of judicial oaths in Scotland. In that country the juror holds up his right hand towards heaven, and swears by Almighty God, and as he shall answer to God at the great day of judgment, "that he will tell the truth, the whole truth, and nothing but the truth, so far as he knows, or it shall be asked of him." This, if administered with dignity and reverence, is an oath sufficiently solemn and well calculated to have the proper effect upon the mind of the juror, as it brings immediately into his view the Author of his being and the awful day of final retribution when every man shall receive the things done in his body according to that he hath done, whether it be good or evil. But when the magistrate, as is too often the case, repeats this solemn invocation without rising from his seat at the name of the supreme Being, and in a tone of carelessness which may convey to the ignorant juror an opinion that he has himself no serious belief that there ever will be a great day of judgment, the form, however excellent, makes not its full impression.

But let us suppose the oath to be administered with the greatest dignity and reverence, the words of the promise itself appear to us by no means unexceptionable. In a trial on life and death, we should be glad to know what this oath binds the witness to declare. Is he to tell *all that he knows* touching the matter in question? or only all that shall be *asked* of him? If he be obliged, in virtue of his oath, to tell all that he knows, the clause—"or it shall be asked of you" is superfluous, and calculated to mislead. If he be bound to tell nothing more of the truth than what shall be asked of him, the word *or* should be changed into *and*; he should swear "to tell the truth, &c. so far as he knows, *and* it shall be asked of him." The court, we believe, considers the witness as bound to declare every thing which he knows touching the matter in question. The greater part of witnesses, on the other hand, consider themselves as bound no farther by their oath than to give true answers to such

questions as shall be asked of them. They would do well, however, to remember, that as oaths are designed for the security of the *public*, they must be interpreted in the sense in which the public intends them, otherwise they afford no security. But the sense of the public is the law; and as it belongs to the court to declare what the mind of the law is, the witness, who has any doubt concerning the extent of the obligation imposed on him by the words of this oath, should apply to the court for a solution of that doubt, which will be a safe guide to him respecting the evidence which he is to give. Should the court, in resolving the doubts of a witness, give an opinion concerning the sense of any other part of the oath contrary to what he apprehends to be the design of the law in imposing it, he is bound to disregard such opinion; because it is only where he himself is doubtful that the court has a right to interfere, and because in all moral questions men must be finally determined by their own judgment and conscience.

There is one case, and but one, in which, whatever sense be put upon the words of the oath, no witness is obliged to declare the *whole* truth. It is when such declaration would tend to accuse himself of some legal crime; for as the laws of Scotland and England constrain no man to become his own accuser, they must be considered as imposing the oath of testimony with this tacit reservation. "The exception, however*, must be confined to *legal* crimes. A point of honour, of delicacy, or of reputation, may make a witness backward to disclose some circumstance with which he is acquainted; but is no excuse for concealment, unless it could be shown, that the law which imposes the oath, intended to allow this indulgence to such motives. The exception is also withdrawn by compact between the magistrate and the witness, when an accomplice is admitted to give evidence against the partners of his crime." But these are a sort of witnesses to whom a sensible jury will always listen with a very cautious ear.

Oaths are either *assertory* or *promissory*. Assertory oaths are required both to confirm our veracity in evidence, and to give security to the public that we *believe* certain propositions conceived to be of public importance. An oath in *evidence* binds the juror to declare what he *knows* to be true, and nothing *but* what he knows to be true. An oath required to assure the public of our *belief* in the *truth* of any proposition, cannot, without the guilt of perjury, be taken by any man, who, at the time of swearing, has the slightest doubt whether the proposition be really true. Such an oath, however, tho' it unquestionably requires the sincerity of the juror's belief at the time when it is given, cannot oblige him to continue in that belief as long as he may live; for belief is not in any man's power: it is the necessary consequence of evidence, which *compels* the assent of the mind according as it appears to preponderate on the one side or on the other. No man, therefore, can be justly accused of perjury for holding opinions contrary to those which he may formerly have sworn to believe; because his belief at the time of emitting his oath may have been the necessary result of the evidence which then appeared before him; and his change of opinion may have resulted with the same necessity from superior evidence

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evidence which had been since thrown into the opposite scale, and made it preponderate. On this account, we cannot help thinking, that all assertory oaths, except such as are necessary to confirm testimony respecting *facts*, ought either to be abolished or expressed with great caution. Of truths intuitively certain or capable of rigid demonstration, no man of common sense can entertain a doubt; and therefore the public never requires from individuals the solemnity of an oath as an assurance of their believing such truths. But with respect to the truth of propositions which admit of nothing superior to moral evidence on either side, a man of the most steady virtue may think differently at different periods of his life; and in such cases, the effect of an oath, if it have any effect, can only be either to shut the man's eyes against the light, or to make his integrity be causelessly questioned by those who shall observe his change of belief.

Promissory oaths cannot, without the guilt of perjury, be given by him, who, at the time of swearing, knows that it will not be in his power to fulfil the promise, or who does not seriously intend to fulfil it. A promissory oath cannot, without great guilt, be given by any man, who at the time of swearing believes the object of the promise to be in itself unlawful; for if he seriously mean to fulfil his oath, he calls upon Almighty God to witness his intention to commit a crime. Promissory oaths give to the public greater security than a simple promise; because the juror having the thoughts of God and of religion more upon his mind at the one time than at the other, offends with a higher hand, and in more open contempt of the divine power, knowledge, and justice, when he violates an oath, than when he breaks a promise. Yet it is certain that promissory oaths, though more solemn and sacred, cannot be binding, when the promise without an oath would not be so in an inferior degree; for the several cases of which, See PROMISE and ALLEGIANCE.

Coronation OATH. See KING.

OATHLAW, the name of a parish in Angus, about two miles from Forfar, chiefly remarkable for the remains of a Roman camp called *Battle-dykes* (vulgarly *Black-dykes*), which is about a mile west of the church.

OBADIAH, or the *Prophecy of OBADIAH*, a canonical book of the Old Testament, which is contained in one single chapter; and is partly an invective against the cruelty of the Edomites, who mocked and derided the children of Israel as they passed into captivity; and with other enemies, their confederates, invaded and oppressed those strangers, and divided the spoil amongst themselves; and partly a prediction of the deliverance of Israel, and of the victory and triumph of the whole church over her enemies.

OBADIAH, the prophet, is believed to have been the same with the governor of Ahab's house, mentioned in the first book of Kings, (xviii. 3, &c.) who hid and fed the hundred prophets whom Jezebel would have destroyed; and some say, that he was that Obadiah whom Josiah made overseer of the works of the temple, (2 Chron. xxxiv. 12.) The truth is, that when he lived or prophesied is wholly uncertain: though

most writers make him cotemporary with Hosea, Amos, and Joel.

OBADIAH, a valiant man of David's army, who came to join him in the wilderness, with several others of the tribe of Gad, (1 Chron. xii. 9.)

This was also the name of one of those whom king Jehoshaphat sent into the cities of Judah to instruct the people in their religion, (2 Chron. xvii. 7.) It was also the name of one of the principal men of Judah, who signed the covenant that Nehemiah renewed with the Lord, (Nehem. x. 5.)

OBED-EDOM, son of Jeduthun, a Levite, (1 Chr. xvi. 38.) and father of Shemaiah, Jehozabad, Joah, Sacar, Nathaneel, Ammiel, Issachar, and Peulthai. He had a numerous family, says the scripture, (1 Chr. xxvi. 4.) because the Lord blessed him; and this is the occasion of this blessing. When David transferred the ark of the covenant to the city of Jerusalem, Uzzah having rashly laid hands on the ark, which he thought to be in danger of falling, was smitten of God, and died upon the spot. David, terrified at this accident, durst not remove the ark into the place he had provided for it in his own house, but set it up in the house of Obed-edom, which was near the place where Uzzah had been struck dead. But the presence of the ark not only created no temporal misfortune to the family of this Levite, but on the contrary the Lord heaped upon him all sorts of blessings; which encouraged David some months after to remove it to the place he had appointed for it. Afterwards Obed-edom and his sons were assigned to be keepers of the doors of the temple, (1 Chron. xv. 18, 21.) In the second book of Samuel, (vi. 10.) Obed-edom is called the Gittite, probably because he was of Gathrimmon, a city of the Levites beyond Jordan, (Josh. xxi. 24, 25.)

OBELISK, in architecture, a truncated, quadrangular, and slender pyramid, raised as an ornament, and frequently charged either with inscriptions or hieroglyphics.

Obelisks appear to be of very great antiquity, and to be first raised to transmit to posterity precepts of philosophy, which were cut in hieroglyphical characters: afterwards they were used to immortalize the great actions of heroes, and the memory of persons beloved. The first obelisk mentioned in history was that of Ramases king of Egypt, in the time of the Trojan war, which was 40 cubits high. Phius, another king of Egypt, raised one of 55 cubits; and Ptolemy Philadelphus, another of 88 cubits, in memory of Arsinoë. Augustus erected one at Rome in the Campus Martius, which served to mark the hours on an horizontal dial, drawn on the pavement. They were called by the Egyptian priests the *fingers of the sun*, because they were made in Egypt also to serve as styles or gnomons to mark the hours on the ground. The Arabs still call them *Pharaoh's needles*; whence the Italians call them *aguglia*, and the French *aiguilles*.

The famous obelisks called the *devil's arrows*, now reduced to three, the fourth having been taken down in the last century, stand about half a mile from the town of Borough-Bridge to the south-west, in three fields, separated by a lane, 200 feet asunder, nearly on high ground sloping every way. Mr Drake urges many

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Obelisk.

Obelisk
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Obolus.

many arguments for their Roman antiquity, and plainly proves them to be natural and brought from Plump-ton quarries about five miles off, or from Ickly 16 miles off. The cross in the town, 12 feet high, is of the same kind of stone. The easternmost or highest is 22 feet and an half high by 4 broad and $4\frac{1}{2}$ in girth; the second $21\frac{1}{2}$ by $55\frac{1}{2}$; the third $16\frac{1}{2}$ by 84. Stukeley's measures differ. The flutings are cut in the stone but not through: the tallest stands alone, and leans to the south. Plot and Stukeley affirm them to be British monuments, originally hewn square. Dr Gale supposed that they were Mercuries, which have lost their heads and inscriptions; but in a MS. note in his Antoninus, he acknowledges that he was misinformed, and that there was no cavity to receive a bust.

On the north side of Penrith in the church-yard are two square obelisks, of a single stone each, 11 or 12 feet high, about 12 inches diameter, and 12 by 8 at the sides, the highest about 18 inches diameter, with something like a transverse piece to each, and mortised into a round base. They are 14 feet asunder, and between them is a grave inclosed between four semicircular stones of the unequal lengths of five, six, and four and an half, and two feet high, having on the outides rude carving, and the tops notched. This is called the *Giant's grave*, and ascribed to Sir Ewan Cæsarius, who is said to have been as tall as one of the columns, and capable of stretching his arms from one to the other, to have destroyed robbers and wild boars in Englewood forest, and to have had an hermitage hereabouts called *Sir Hugh's parlour*; but the conjectures respecting them are so various and contradictory, that our readers will readily excuse our enlarging on them.

A little to the west of these is a stone called the *Giant's Thumb*, six feet high, 14 inches at the base contracted to 10, which is no more than a rude cross, such as is at Langtown in Cumberland and elsewhere: the circle of the cross 18 inches diameter.

M. Pouchard, in the memoirs of the Academy of Inscriptions, gives a very curious account of some celebrated Egyptian obelisks. We cannot afford room to follow him; but those who wish for further information on the subject, and who are not possessed of the original, will find a very good account of them in the *Gentleman's Magazine* for June 1748.

OBJECT, in philosophy, something apprehended or presented to the mind by sensation or imagination. See *METAPHYSICS*, Part I. Chap. I. Sect. II.

OBJECT-Glass of a *Telescope*, or *Microscope*, the glass placed at the end of the tube which is next the object. See *OPTICS* and *MICROSCOPE*.

OBJECTION, something urged to overthrow a position, or a difficulty raised against an allegation or proposition of a person we are disputing with.

OBJECTIVE, is used in the schools, in speaking of a thing which exists no otherwise than as an object known. The existence of such a thing is said to be objective.

OBIT, (Lat.) signifies a funeral solemnity, or office for the dead, most commonly performed when the corpse lies in the church uninterred: Also the anniversary office, (2 Cro. 51 Dyer 313). The anniversary of any person's death was called the *obit*; and to observe such day with prayers and alms, or other com-

memoration, was the keeping of the obit. In religious houses they had a register, wherein they entered the obits or obitual days of their founders and benefactors; which was thence termed the *obituary*. The tenure of obit or chantry lands is taken away and extinct by 1 Edw. VI. c. 14. and 15 Car. II. c. 9.

OBLATI, in church-history, were secular persons, who devoted themselves and their estates to some monastery, into which they were admitted as a kind of lay-brothers. The form of their admission was putting the bell-ropes of the church round their necks, as a mark of servitude. They wore a religious habit, but different from that of the monks.

OBLIGATION, in general, denotes any act whereby a person becomes bound to another to do something; as to pay a sum of money, be surety, or the like.

Obligations are of three kinds, viz. natural, civil, and mixed. Natural obligations are entirely founded on natural equity; civil obligation on civil authority alone, without any foundation in natural equity; and mixed obligations are those which, being founded on natural equity, are farther enforced by a civil authority.

In a legal sense, obligation signifies a bond, wherein is contained a penalty, with a condition annexed for the payment of money, &c. The difference between it and a bill is, that the latter is generally without a penalty or condition, though it may be made obligatory: and obligations are sometimes by matter of record, as statutes and recognizances. See the article *BOND*.

Moral OBLIGATION. See *MORAL PHILOSOPHY*, n^o 58, &c.

OBLIQUE, in geometry, something aslant, or that deviates from the perpendicular. Thus an oblique angle is either an acute or obtuse one, i. e. any angle except a right one.

OBLIQUE Cases, in grammar, are all the cases except the nominative. See *GRAMMAR*.

OBLIQUE Line, that which, falling on another line, makes oblique angles with it, viz. one acute, and the other obtuse.

OBLIQUE Planes, in dialling, are those which decline from the zenith, or incline towards the horizon. See *DIAL*.

OBLIQUE Sailing, in navigation, is when a ship sails upon some rhumb between the four cardinal points, making an oblique angle with the meridian; in which case she continually changes both latitude and longitude. See *NAVIGATION*, chap. 8.

OBLIQUUS, in anatomy, a name given to several muscles, particularly in the head, eyes, and abdomen. See *ANATOMY*, *Table of the Muscles*.

OBLONG, in general, denotes a figure that is longer than broad: such is a parallelogram.

OBOLARIA, in botany: A genus of the angiospermia order, belonging to the didynamia class of plants; and in the natural method ranking under the 40th order, *Personata*. The calyx is bifid; the corolla campanulated and quadrid; the capsule unilocular, bivalved, and polyspermous; the stamina rising from the divisions of the corolla.

OBOLUS, an ancient silver money of Athens, the sixth part of a drachma; worth somewhat more than a

Obolus
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Observa-
tory.

penny-farthing Sterling.—The word comes from the Greek *ὀβολός*, or *ὀβελός*, “spit, or broach;” either because it bore such an impression; or because, according to Eustathius, it was in form thereof. But those now in the cabinets of the antiquaries are round.

OBOLUS, in medicine, is used for a weight of ten grains, or half a scruple.

OBOTH, an encampment of the Hebrews in the wilderness. From Punon they went to Oboth, and from Oboth to Je-abarim, (Numb. xxi. 10. xxxiii. 43.) Ptolemy speaks of a city called Oboda, or Eboda, in Arabia Petræa, which is the same as Oboth. Pliny and the geographer Stephanus mention it also. Stephanus makes it belong to the Nabathæans, and Pliny to the Helmodæans, a people of Arabia. It was at Oboth that they worshipped the god Obodos, which Tertullian joins with Dufares, another god or king of this country.

OBRECHT (Ulric), a learned German, born of a noble family at Strasburg in 1646, where he filled the chairs of civil law and history with great distinction. He was of the Protestant religion; but when Louis XIV. made himself master of Strasburg, and went there with his court, he was prevailed on to change; and accordingly abjured in 1684, and put his instrument into the hands of Bossuet bishop of Meaux. The next year the king nominated him to preside in his name in the senate of Strasburg, with the title of prætor royal, in imitation of the ancient Romans; from which time Mr Obrecht applied himself entirely to public affairs. He was the editor, translator, and writer, of several learned works; and died in 1701.

OBREPTITIOUS, an appellation given to letters patent, or other instruments, obtained of a superior by surprise, or by concealing from him the truth.

OBSCURE, something that is dark and reflects little light in material objects, or that is not clear and intelligible in the objects of the intellect.

OBSECRATION, in rhetoric, a figure whereby the orator implores the assistance of God or man.

OBSEQUENS (Julius), a Latin writer, conjectured to have lived before the emperor Honorius's reign. He made a collection of the prodigies which Livy related in his history. There are several editions of those remains. Lycosthenes endeavoured to supply what was wanting in the original.

OBSEQUIES, the same with funeral solemnities. See FUNERAL.

OBSERVATION, among navigators, signifies the taking the sun's or the stars meridian altitude, in order thereby to find the latitude.

OBSERVATORY, a place destined for observing the heavenly bodies; being generally a building erected on some eminence, covered with a terrace for making astronomical observations.

The more celebrated observatories are, 1. The Greenwich observatory, built in 1676, by order of Charles II. at the solicitation of Sir Jonas Moore and Sir Christopher Wren; and furnished with the most accurate instruments; particularly a noble sextant of seven feet radius, with telescopic sights.

2. The Paris observatory, built by the order of Louis XIV. in the Fauxbourg St Jacques.

It is a very singular, but withal a very magnificent

building, the design of Monsieur Perault: it is 80 feet high; and at top is a terrace.

The difference in longitude between this and the Greenwich observatory is 2° 20'.

In it is a cave or cellar, of 170 feet descent, for experiments that are to be made far from the sun, &c. particularly such as relate to congelations, refrigerations, indurations, conservations, &c.

3. Tycho Brahe's observatory, which was in the little island Ween, or Scarlet Island, between the coasts of Schonen and Zealand in the Baltic. It was erected and furnished with instruments at his own expence, and called by him *Uraniburg*. Here he spent twenty years in observing the stars; the result is his catalogue.

4. Pekin observatory. Father Le Compte describes a very magnificent observatory, erected and furnished by the late emperor of China, in his capital, at the intercession of some Jesuit missionaries, principally Father Verbeist, whom he made his chief observer.—The instruments are exceedingly large; but the division less accurate, and the contrivance in some respects less commodious, than that of the Europeans. The chief are, An armillary zodiacal sphere of six feet diameter; an equinoctial sphere of six feet diameter; an azimuthal horizon of six feet diameter; a large quadrant six feet radius; a sextant eight feet radius; and a celestial globe six feet diameter.

Observatories, as they are very useful, and indeed absolutely necessary for astronomers, so they have become far more common than they were. There is a very excellent one now at Oxford, built by the trustees of Dr Radcliffe, at the expence of nearly 30,000 l. At Cambridge there is as yet no public observatory. Over the great gate of Trinity college, indeed, there is one which is called *Sir Isaac Newton's*, because this great philosopher had used it; but it is gone to decay. It were well if the university would repair and preserve it in memory of that truly great man. In St John's, too, there is a small one. The late ingenious Mr Cotes had used to give lectures in Sir Isaac Newton's on experimental philosophy. There are several very good ones in the Scotch universities; and there is an excellent one lately erected at Dublin.

5. Bramins observatory at Benares. Of this Sir Robert Barker gives the following account, (Phil. Transf. Vol LXVII. p. 598.) “Benares in the East Indies, one of the principal seminaries of the Bramins or priests of the original Gentoos of Hindoستان, continues still to be the place of resort of that sect of people; and there are many public charities, hospitals, and pagodas, where some thousands of them now reside. Having frequently heard that the ancient Bramins had a knowledge of astronomy, and being confirmed in this by their information of an approaching eclipse both of the sun and moon, I made inquiry, when at that place in the year 1772, among the principal Bramins, to endeavour to get some information relative to the manner in which they were acquainted of an approaching eclipse. The most intelligent that I could meet with, however, gave me but little satisfaction. I was told, that these matters were confined to a few, who were in possession of certain books and records; some containing the my-
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Observatory.

Observatory.

teries of their religion; and others the tables of astronomical observations, written in the Sanscrit language, which few understood but themselves: that they would take me to a place which had been constructed for the purpose of making such observations as I was inquiring after, and from whence they supposed the learned Bramins made theirs. I was then conducted to an ancient building of stone, the lower part of which, in its present situation, was converted into a stable for horses, and a receptacle for lumber; but, by the number of court-yards and apartments, it appeared that it must once have been an edifice for the use of some public body of people. We entered this building, and went up a staircase to the top of a part of it, near to the river Ganges, that led to a large terrace, where, to my surprise and satisfaction, I saw a number of instruments yet remaining, in the greatest preservation, stupendously large, immoveable from the spot, and built of stone, some of them being upwards of 20 feet in height; and although they are said to have been erected 200 years ago, the graduations and divisions on the several arcs appeared as well cut, and as accurately divided, as if they had been the performance of a modern artist. The execution in the construction of these instruments exhibited a mathematical exactness in the fixing, bearing, fitting of the several parts, in the necessary and sufficient supports to the very large stones that composed them, and in the joining and fastening each into the other by means of lead and iron.

"The situation of the two large quadrants of the instrument marked A in the plate, whose radius is nine feet two inches, by their being at right angles with a gnomon at twenty-five degrees elevation, are thrown into such an oblique situation as to render them the most difficult, not only to construct of such a magnitude, but to secure in their position for so long a period, and affords a striking instance of the ability of the architect in their construction: for, by the shadow of the gnomon thrown on the quadrants, they do not appear to have altered in the least from their original position; and so true is the line of the gnomon, that, by applying the eye to a small iron ring of an inch diameter at one end, the sight is carried through three others of the same dimension, to the extremity at the other end, distant 38 feet 8 inches, without obstruction; such is the firmness and art with which this instrument has been executed. This performance is the more wonderful and extraordinary when compared with the works of the artificers of Hindostan at this day, who are not under the immediate direction of an European mechanic; but arts appear to have declined equally with science in the east.

"Lieutenant colonel Archibald Campbell, at that time chief engineer in the East India Company's service at Bengal, made a perspective drawing of the whole of the apparatus that could be brought within his eye at one view; but I lament he could not represent some very large quadrants, whose radii were about twenty feet, they being on the side from whence he took his drawing. Their description however is, that they are exact quarters of circles of different radii, the largest of which I judged to be 20 feet, constructed very exactly on the sides of stone-walls, built perpendicular, and situated, I suppose, in the meridian of the place: a brass pin is fixed at the

centre or angle of the quadrant, from whence, the Bramin informed me, they stretched a wire to the circumference when an observation was to be made; from which it occurred to me, the observer must have moved his eye up or down the circumference, by means of a ladder or some such contrivance, to raise and lower himself, until he had discovered the altitude of any of the heavenly bodies in their passage over the meridian, so expressed on the arcs of these quadrants; these arcs were very exactly divided into nine large sections; each of which again into ten, making ninety lesser divisions or degrees; and those also into twenty, expressing three minutes each, of about two-tenths of an inch asunder; so that it is probable they had some method of dividing even these into more minute divisions at the time of observation.

"My time would only permit me to take down the particular dimensions of the most capital instrument, or the greater equinoctial sun-dial, represented by figure A, which appears to be an instrument to express solar time by the shadow of a gnomon upon two quadrants, one situated to the east, and the other to the west of it; and indeed the chief part of their instruments at this place appear to be constructed for the same purpose, except the quadrants, and a brass instrument that will be described hereafter.

"Figure B is another instrument for the purpose of determining the exact hour of the day by the shadow of a gnomon, which stands perpendicular to, and in the centre of, a flat circular stone, supported in an oblique situation by means of four upright stones and a cross-piece; so that the shadow of the gnomon, which is a perpendicular iron-rod, is thrown upon the division of the circle described on the face of the flat circular stone.

"Figure C is a brass circle, about two feet diameter, moving vertically upon two pivots between two stone pillars, having an index or hand turning round horizontally on the centre of this circle, which is divided into 360 parts; but there are no counter-divisions on the index to subdivide those on the circle. This instrument appears to be made for taking the angle of a star at setting or rising, or for taking the azimuth or amplitude of the sun at rising or setting.

"The use of the instrument, figure D, I was at a loss to account for. It consists of two circular walls; the outer of which is about forty feet diameter, and eight feet high; the wall within about half that height, and appears intended for a place to stand on to observe the divisions on the upper circle of the outer wall, rather than for any other purpose; and yet both circles are divided into 360 degrees, each degree being subdivided into twenty lesser divisions, the same as the quadrants. There is a door-way to pass into the inner circle, and a pillar in the centre, of the same height with the lower circle, having a hole in it, being the centre of both circles, and seems to be a socket for an iron-rod to be placed perpendicular into it. The divisions on these, as well as all the other instruments, will bear a nice examination with a pair of compasses.

"Figure E is a smaller equinoctial sun-dial, constructed upon the same principle as the large one A.

"I cannot quit this subject without observing, that the Bramins, without the assistance of optical glasses,

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glasses, had nevertheless an advantage unexperienced by the observers of the more northern climates. The serenity and clearness of the atmosphere in the night-time in the East Indies, except at the seasons of changing the monsoons or periodical winds, is difficult to express to those who have not seen it, because we have nothing in comparison to form our ideas upon: it is clear to perfection, a total quietude subsists, scarcely a cloud to be seen, and the light of the heavens, by the numerous appearance of the stars, affords a prospect both of wonder and contemplation.

"This observatory at Benares is said to have been built by the order of the emperor Ackbar: for as this wise prince endeavoured to improve the arts, so he wished also to recover the sciences of Hindostan, and therefore directed that three such places should be erected; one at Delhi, another at Agra, and the third at Benares."

Edinburgh OBSERVATORY. See EDINBURGH.

OBSIDIANUS LAPIS, in the natural history of the ancients, the name of a stone which they have also described under the name of the *Chian marble*. It is a very smooth and hard marble, extremely difficult to cut, but capable of a fine polish; and was used among the ancient Greeks for the purpose of making reflecting mirrors. The later writers have supposed the name *obsidianus* to be derived from somebody called *Obsidius*, who was the inventor of this use of it; but it seems only a false spelling of the word *opifianus*, *απο της οψις*, from seeing the images of things in it. See *GALLINACEUS Lapis*.

OBSIDIONALIS, an epithet applied by the Romans to a sort of crown. See the article **CROWN**.

OBSTETRICS, or the **OBSTETRIC ART**, the same with **MIDWIFERY**.

OBSTRUCTION, in medicine, such an obturation of the vessels as prevents the circulation of the fluids, whether of the sound and vital, or of the morbid and peccant kind, through them.

OBTURATOR, in anatomy. See **ANATOMY**, *Table of the Muscles*.

OBTUSE, signifies blunt, dull, &c. in opposition to acute or sharp. Thus we say, obtuse angle, obtuse-angled triangle, &c.

OBY, or **OB**, a large and famous river of Asiatic Russia, which issues from the Altin lake (called by the Russians *Telekoi-Osero*), in latitude 52 degrees, and longitude 103 degrees 30 minutes. Its name signifies *Great*; and accordingly in Russia it is often styled the *Great River*. The Calmucks and Tartars call it *Umar*. Its stream is very large and smooth, its current being usually slow; and it is in general between two and three hundred fathoms broad; though in some places it is much wider. It affords plenty of fish, and is navigable almost to the lake from which it springs. After a long winding course through a vast tract of land, in which it forms several islands, it empties itself in latitude 67 degrees, and longitude 86 degrees, into a bay, which, extending near 400 miles farther, joins the Ice Sea in latitude 73. 30. and longitude 90. The springs from which this river rises, are not very copious; but it receives in its course the waters of a great number of considerable streams. Of these, the Tom and the Irtis are the

N^o 245.

most considerable: the Tom falls into it in Lat. 58. and the Irtis in Lat. 61. and Long. 86. The exact course of this river was unknown, till the country was surveyed by the Russians; who have given us tolerable maps of it and of all Siberia. The Oby forms the boundary between Europe and Asia, and its course is upwards of 2000 miles in length.

OCCIDENT, in geography, the westward quarter of the horizon; or that part of the horizon where the ecliptic, or the sun therein, descends into the lower hemisphere; in contradistinction to *orient*. Hence we use the word *occidental* for any thing belonging to the west; as *occidental bezoar*, *occidental pearl*, &c.

OCCIPITAL, in anatomy, a term applied to the parts of the occiput, or back part of the skull.

OCCULT, something hidden, secret, or invisible. The occult sciences are magic, necromancy, cabbala, &c. Occult qualities, in philosophy, were those qualities of body or spirit which baffled the investigation of philosophers, and for which they were unable to give any reason: unwilling however to acknowledge their ignorance, they deceived themselves and the vulgar by an empty title, calling what they did not know *occult*.

OCCULT, in geometry, is used for a line that is scarce perceivable, drawn with the point of the compasses or a leaden pencil. These lines are used in several operations, as the raising of plans, designs of building, pieces of perspective, &c. They are to be effaced when the work is finished.

OCCULTATION, in astronomy, the time a star or planet is hid from our sight, by the interposition of the body of the moon or some other planet.

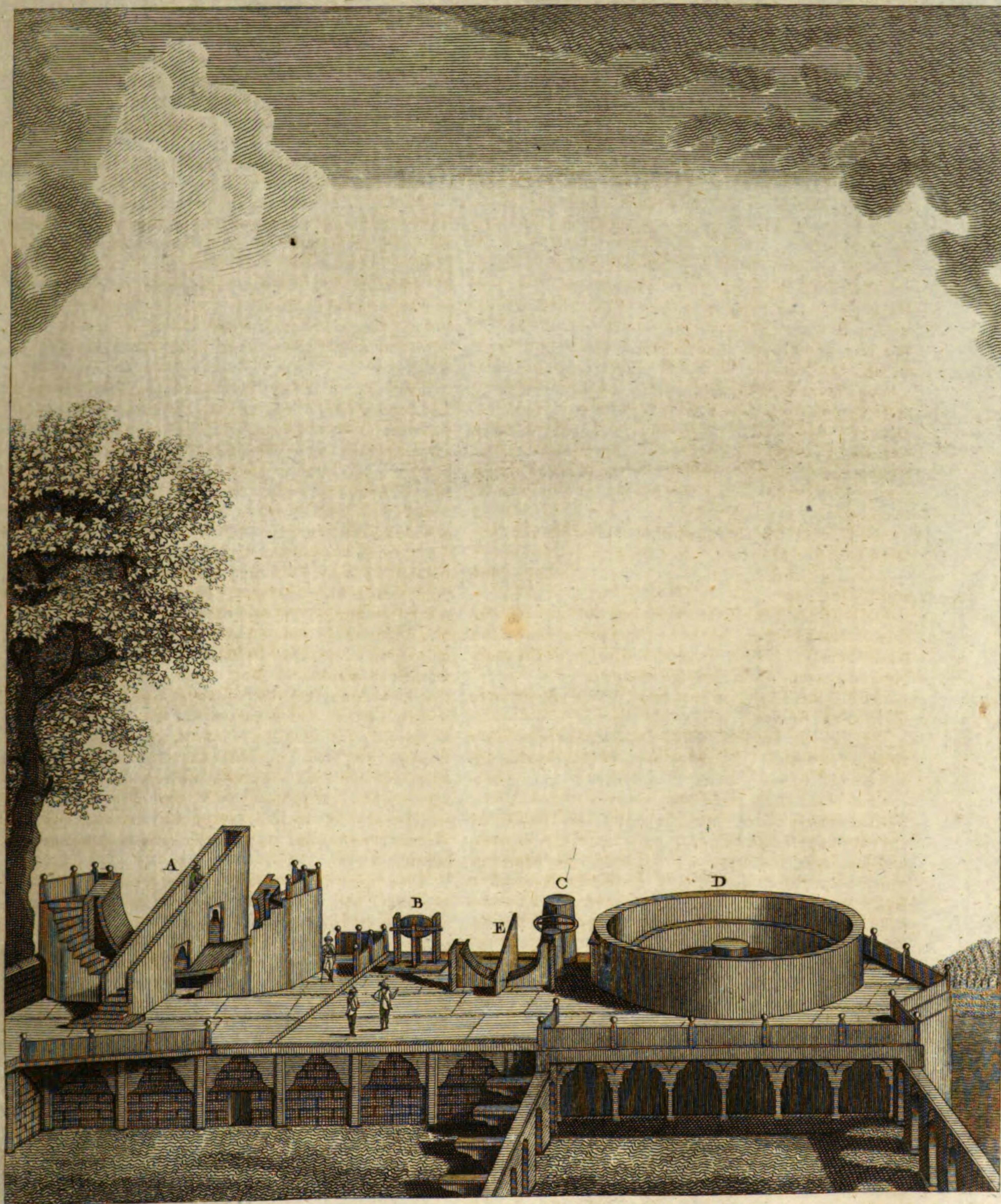
OCCUPANCY, in law, is the taking possession of those things which before belonged to nobody. This is the true ground and foundation of all **PROPERTY**, or of holding those things in severalty, which by the law of nature, unqualified by that of society, were common to all mankind. But, when once it was agreed that every thing capable of ownership should have an owner, natural reason suggested, that he who could first declare his intention of appropriating any thing to his own use, and, in consequence of such his intention, actually took it into possession, should thereby gain the absolute property of it; according to that rule of the law of nations, recognised by the laws of Rome, *Quod nullius est, id ratione naturali occupanti conceditur*.

This right of occupancy, so far as it concerns real property, hath been confined by the laws of England within a very narrow compass; and was extended only to a single instance; namely, where a man was tenant *pour autre vie*, or had an estate granted to himself only (without mentioning his heirs) for the life of another man, and died during the life of *cestuy que vie*, or him by whose life it was holden: in this case, he that could first enter on the land, might lawfully retain the possession so long as *cestuy que vie* lived, by right of occupancy.

This seems to have been recurring to first principles, and calling in the law of nature to ascertain the property of the land, when left without a legal owner. For it did not revert to the granter, who had parted with all his interest, so long as *cestuy que vie* lived; it

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A. Bell Pin. W. A. Sculptor fecit.

Occupancy. did not escheat to the lord of the fee; for all escheats must be of the absolute entire fee, and not of any particular estate carved out of it, much less of so minute a remnant as this: it did not belong to the grantee; for he was dead: it did not descend to his heirs; for there were no words of inheritance in the grant: nor could it vest in his executors; for no executors could succeed to a freehold. Belonging therefore to nobody, like the *hereditas jacens* of the Romans, the law left it open to be seized and appropriated by the first person that could enter upon it, during the life of *cestuy que vie*, under the name of an occupant. But there was no right of occupancy allowed, where the king had the reversion of the lands: for the reversioner hath an equal right with any other man to enter upon the vacant possession; and where the king's title and a subject's interfere, the king's shall always be preferred. Against the king therefore there could be no prior occupant, because *nullum tempus occurrit regi*. And, even in the case of a subject, had the estate *pour autre vie* granted to a man and his heirs during the life of *cestuy qui vie*, there the heir might, and still may, enter and hold possession, and is called in law a *special occupant*; as having a special exclusive right, by the terms of the original grant, to enter upon and occupy this *hereditas jacens*, during the residue of the estate granted: though some have thought him so called with no very great propriety; and that such estate is rather a descendible freehold. But the title of *common occupancy* is now reduced almost to nothing by two statutes; the one, 29 Car. II. c. 3. which enacts, that where there is no special occupant, in whom the estate may vest, the tenant *pour autre vie* may devise it by will, or it shall go to the executors, and be assets in their hands for payment of debts: the other that of 14 Geo. II. c. 20. which enacts, that it shall vest not only in the executors, but, in case the tenant dies intestate, in the administrators also; and go in course of a distribution like a chattel interest.

By these two statutes the title of *common occupancy* is utterly extinct and abolished: though that of *special occupancy*, by the heir at law, continues to this day; such heir being held to succeed to the ancestor's estate, not by descent, for then he must take an estate of inheritance, but as an occupant, specially marked out and appointed by the original grant. The doctrine of common occupancy may, however, be usefully remembered on the following account, amongst others: That, as by the common law no occupancy could be of incorporeal hereditaments, as of rents, tithes, advowsons, commons, or the like, (because, with respect to them, there could be no actual entry made, or corporal seisin had; and therefore by the death of the grantee *pour autre vie* a grant of such hereditaments was entirely determined): so now, it is apprehended, notwithstanding those statutes, such grant would be determined likewise; and the hereditaments could not be deviseable, nor vest in the executors, nor go in a course of distribution. For the statutes must not be construed so as to create any new estate, or to keep that alive which by the common law was determined, and thereby to defeat the grantor's reversion; but merely to dispose of an interest in being, to which by law there was no owner, and which therefore was left open to the first occupant. When there is a residue

left, the statutes give it to the executors, &c. instead of the first occupant; but they will not create a residue on purpose to give it to the executors. They only mean to provide an appointed instead of a casual, a certain instead of an uncertain, owner, of lands which before were nobody's; and thereby to supply this *casus omissus*, and render the disposition of the law in all respects entirely uniform: this being the only instance wherein a title to a real estate could ever be acquired by occupancy.

For there can be no other case devised, wherein there is not some owner of the land appointed by the law. In the case of a sole corporation, as a parson of a church, when he dies or resigns, though there be no *actual* owner of the land till a successor be appointed, yet there is a *legal, potential*, ownership, subsisting in contemplation of law; and when the successor is appointed, his appointment shall have a retrospect and relation backwards, so as to entitle him to all the profits from the instant that the vacancy commenced. And, in all other instances, when the tenant dies intestate, and no other owner of the lands is to be found in the common course of descents, there the law vests an ownership in the king, or in the subordinate lord of the fee, by escheat.

So also, in some cases, where the laws of other nations give a right by occupancy, as in lands newly created, by the rising of an island in a river, or by the alluvion or dereliction of the sea; in these instances, the law of England assigns them an immediate owner. For Bracton tells us, that if an island arise in the *middle* of a river, it belongs in common to those who have lands on each side thereof; but if it be nearer to one bank than the other, it belongs only to him who is proprietor of the nearest shore: which is agreeable to, and probably copied from, the civil law. Yet this seems only to be reasonable, where the soil of the river is equally divided between the owners of the opposite shores: for if the whole soil is the freehold of any one man, as it must be whenever a several fishery is claimed, there it seems just (and so is the usual practice) that the islets, or little islands, arising in any part of the river, shall be the property of him who owneth the piscary and the soil. However, in case a new island rise in the *sea*, though the civil law gives it to the first occupant, yet our's gives it to the king. And as to lands gained from the sea; either by *alluvion*, by the washing up of sand and earth, so as in time to make *terra firma*; or by *dereliction*, as when the sea shrinks back below the usual water-mark; in these cases the law is held to be, that if this gain be by little and little, by small and imperceptible degrees, it shall go to the owner of the land adjoining. For *de minimis non curat lex*: and, besides, these owners being often losers by the breaking in of the sea, or at charges to keep it out, this possible gain is therefore a reciprocal consideration for such possible charge or loss. But if the alluvion or dereliction be sudden and considerable, in this case it belongs to the king: for, as the king is lord of the sea, and so owner of the soil while it is covered with water, it is but reasonable he should have the soil when the water has left it dry. So that the quantity of ground gained, and the time during which it is gained, are what make it either the king's or the subject's property. In the same manner,

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Oceanides.

if a river, running between two lordships, by degrees gains upon the one, and thereby leaves the other dry; the owner who loses his ground thus imperceptibly has no remedy: but if the course of the river be changed by a sudden and violent flood, or other hasty means, and thereby a man loses his ground, he shall have what the river has left in any other place as a recompense for this sudden loss. And this law of alluvions and derelictions, with regard to *rivers*, is nearly the same in the imperial law; from whence indeed those our determinations seem to have been drawn and adopted: but we ourselves, as islanders, have applied them to *marine* increases; and have given our sovereign the prerogative he enjoys, as well upon the particular reasons before-mentioned, as upon this other general ground of prerogative, which was formerly remarked, that whatever hath no other owner is vested by law in the king. See PREROGATIVE.

OCCUPANT, in law, the person that first seizes or gets possession of a thing.

OCCUPATION, in a legal sense, is taken for use or tenure: as in deeds it is frequently said, that such lands are, or were lately, in the tenure or occupation of such a person.—It is likewise used for a trade or mystery.

OCCUPIERS of WALLING, a term used in the salt-works for the persons who are the sworn officers that allot in particular places what quantity of salt is to be made, that the markets may not be overstocked, and see that all is carried fairly and equally between the lord and the tenant.

OCEAN, that huge mass of salt waters which encompasses all parts of the globe, and by means of which, in the present improved state of navigation, an easy intercourse subsists between places the most distant.

The ocean is distinguished into three grand divisions. 1. The Atlantic ocean, which divides Europe and Africa from America, which is generally about 3000 miles wide. 2. The Pacific ocean, or South-sea, which divides America from Asia, and is generally about 10,000 miles over. And, 3. The Indian ocean, which separates the East Indies from Africa; which is 3000 miles over. The other seas, which are called *oceans*, are only parts or branches of these, and usually receive their names from the countries they border upon.

For the saltness, tides, &c. of the ocean, see the articles SEA, TIDES, &c.

OCEANIDES (fab. hist.), sea-nymphs, daughters of Oceanus, from whom they received their name, and of the goddesses Tethys or Thetis. They were 3000 according to Apollodorus, who mentions the names of seven of them; Asia, Styx, Electra, Donis, Eurynome, Amphitrite, and Metis. Hesiod speaks of the eldest of them, which he reckons 41, Pitho, Admete, Prynno, Ianthé, Rhodia, Hippos, Callirhoe, Urania, Clymene, Idyia, Pasithoe, Clythia, Zeuxo, Galuxaure, Plexaure, Perseis, Pluto, Thoe, Polydora, Melobosis, Dione, Cerceis, Xanthé, Acasta, Ianira, Telestho, Europa, Menestho, Petrea, Eudora, Calypso, Tyche, Ocyroe, Crisia, Amphiro, with those mentioned by Apollodorus, except Amphitrite. Hyginus mentions 16 whose names are almost all different from those of Apollodorus and Hesiod; which difference proceeds from the mutilation of the original text. The Oceanides, like

the rest of the inferior deities, were honoured with libations and sacrifices. Prayers were offered to them, and they were entreated to protect sailors from storms and dangerous tempests. The Argonauts, before they proceeded to their expedition, made an offering of flour, honey, and oil, on the sea-shore, to all the deities of the sea, and sacrificed bulls to them, and intreated their protection. When the sacrifice was made on the sea-shore, the blood of the victim was received in a vessel; but when it was in open sea, they permitted the blood to run down into the waters. When the sea was calm, they generally offered a lamb or a young pig; but if it was agitated by the winds and rough, a black bull was deemed the most acceptable victim.

OCEANUS, in Pagan mythology, the son of Cœlus and Terra, the husband of Thetis, and the father of the rivers and fountains, called *Oceanides*. The ancients called him the *Father of all things*, imagining that he was produced by Humidity, which, according to Thales, was the first principle from which every thing was produced. Homer represents Juno visiting him at the remotest limits of the earth, and acknowledging him and Thetis as the parents of the gods. He was represented with a bull's head, as an emblem of the rage and bellowing of the ocean when agitated by a storm.

According to Homer, he was the father even of all the gods, and on that account he received frequent visits from them. He is often, indeed almost always, represented as an old man with a long flowing beard, and sitting upon the waves of the sea. He often holds a pike in his hand, while ships under sail appear at a distance, or a sea monster stands near him. Oceanus presided over every part of the sea, and even the rivers were subjected to his power. The ancients were superstitious in their worship of him, and revered with great solemnity a deity to whose care they entrusted themselves when going on any voyage.

OCEIA, a woman who presided over the sacred rites of Vesta for 57 years with the greatest sanctity. She died in the reign of Tiberius, and the daughter of Domitius succeeded her.

OCELLUS the LUCANIAN, an ancient Greek philosopher of the school of Pythagoras, who lived before Plato. His work *περί τοῦ Παντός*, or "The Universe," is the only piece of his which is come down entire to us; and was written originally in the Doric dialect, but was translated by another hand into the Attic. William Christian, and after him Lewis Nogarola, translated this work into Latin; and we have several editions of it, both in Greek and Latin.

OCELOT, the Mexican cat. See FELIS.

OCELOXOCHITL, or TYGER-FLOWER, in botany: A large Mexican plant, composed of three pointed petals, red, but towards the middle of a mixed white and yellow, representing in some degree the spots of that wild animal from which it takes its name. The plant has leaves also resembling those of the iris, and a bulbous root. See Plate CCCL.

OCHINUS (Bernardin), a celebrated Italian, was born at Siene in 1487, and first became a Cordelier: but he quickly returned into the world, applied himself to the study of physic, and acquired the esteem of cardinal Julius de Medicis, afterwards Pope Clement VII. At length, again changing his mind, he resumed

Oceanus
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Ochinus.

Ochinus. med his monk's habit in a penitential mood; and not content with this, but aiming at higher perfection, he embraced in 1534 the reformed sect of the Capuchins. He practised, with a most rigorous exactness, all the rules of the order; which, being then in its infancy, he contributed so much to improve and enlarge, that some writers have called him the founder of it. He was certainly made vicar-general of it, and became in the highest degree eminent for his pulpit eloquence. He delivered his sermons with so much grace and politeness, and spoke so copiously, that he ravished his audience wherever he was: never indeed was a man more successful or more applauded. His extraordinary merit procured him the favour of Pope Paul III. who, it is said, made him his father confessor and preacher. He was thus the darling both of prince and people; when, falling into the company of one John Valde a Spaniard, who had imbibed Luther's doctrine in Germany, he became a profelyte. He was then at Naples, and began to preach in favour of Protestantism: which being observed, he was summoned to appear at Rome; and was in his way thither when he met at Florence Peter Martyr, with whom, it is probable, he had become acquainted at Naples. This friend persuaded him not to put himself into the pope's power; and they both agreed to withdraw to some place of safety. *Ochinus* went first to Ferrara, where he disguised himself in the dress of a soldier; and proceeding thence to Geneva, arrived there in 1542, and married a woman of Lucca. He did not, however, settle there, but went to Augsburg, where he published some sermons.

In 1547 he was invited, together with Peter Martyr, into England by Archbishop Cranmer, that he might have their joint assistance in carrying on the reformation. They arrived in December; and going to Lambeth, were kindly received by Cranmer. They were entertained there for some time; and *Ochinus*, as well as Martyr, was made a prebendary of Canterbury (A). He laboured heartily in the conduct of the reformation; and his dialogue upon the unjust usurped primacy of the bishop of Rome was translated into Latin by Ponet bishop of Winchester, and published in 1549. But upon the death of Edward VI. being forced as well as Martyr to leave England, they retired to Strasburg, where they arrived in 1553. From this city *Ochinus* went to Basil, and was invited thence in 1555 to Zurich, to be minister of an Italian church which was gathering there. This church consisted of some refugees from Locarno, one of the four bailiwicks which the Switzers possess in Italy; they being hindered from the public exercise of the reformed religion by the opposition of the Popish cantons. *Ochinus* had no difficulty to subscribe the articles of faith agreed upon by the church of Zurich, and met in that city with Bullinger, who proved a very good friend to him. He governed this Italian church till 1563, when he was banished thence by the magistrates of the town for publishing some dialogues, wherein he defended the doctrine of polygamy. From Zurich he went to Basil; but not being suffered to stay there, he fled in

great distress into Moravia, where he fell in with the Socinians, and joined them. Stanislaus Lubienietzki, the great patron of this sect, gives the following account of his last days in his *Hist. Reformat. Polon.* *Ochinus*, says he, retired into Moravia, and into Poland, and even there he was not out of the reach of Calvin's letters. He returned into Moravia after king Sigismund's edict; who in 1564 punished with banishment all those that were called Tritheists, Atheists, &c. Some gentlemen endeavoured to keep him in Poland; but he answered, that men must obey the magistrates, and that he would obey them, even were he to die among the wolves in the woods. During his travels, he fell sick of the plague at Pinckfow, and received there all possible offices of kindness from one of the brethren, named Philippovius. His daughter and two sons, whom he carried along with him, died of the plague; but he had buried his wife before he had left Zurich. As for himself, he continued his journey to Moravia, and within three weeks died at Slakow, in 1564, aged 77.

His character is variously represented by different authors, as was to be expected; for men like him have all manner of things, good and bad, said and written of them, by somebody or other. Bayle says, that the confession he made publicly, on the change of his religion, is remarkable. He acknowledged, in a preface, that if he could have continued, without danger of his life, to preach the truth, after the manner he had preached it for some years, he would never have laid down the habit of his order; but as he did not find within himself that courage which is requisite to undergo martyrdom, he took sanctuary in a Protestant country. His writings are numerous, but not bulky.

OCHLOCRACY, that form of government where in the populace have the chief administration of affairs.

OCHNA, in botany: A genus of the monogynia order, belonging to the polyandria class of plants; and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous; the calyx pentaphyllous; the berries monospermous, and affixed to a large roundish receptacle.

OCHRE, in natural history, a genus of earths, slightly coherent, and composed of fine, smooth, soft, argillaceous particles, rough to the touch, and readily diffusible in water. Ochres are of various colours, as red, blue, yellow, brown, green, &c.

OCHROMA, in botany: A genus of the pentandria order, belonging to the monodelphia class of plants; and in the natural method ranking under the 37th order, *Columnifera*. The corolla consists of six petals, three of which are external, and the other three internal; the antheræ unite and form a spiral pillar round the style; the capsule is long, and has five loculaments, and contain a number of black round seeds. Of this there is only one species, viz. the ochroma lagopus, the downtree or corkwood. This tree is frequent in Jamaica, is of speedy growth, and rises to about 25 or 30 feet. The flowers are large and yellow. The capsules are about five inches long, round-

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(A) According to Wood, Athen. Oxon. but it rests solely on his authority, so far as we know.

Ochinus
||
Ochroma.

Ochus
Ockham.

ed, and covered with a thin skin; which when dry falls off in five longitudinal segments, and leaves the fruit greatly resembling a hare's foot. The down is short, soft, and silky: it is used sometimes to stuff beds and pillows; but, like other vegetable downs, is apt to get into clots: an insipid clear gum exudes from the tree when wounded. The bark is tough, and its fibres are in a reticulated form: it might be made into ropes. The dried wood is so very light and buoyant, as to be used by the fishermen in Jamaica for their nets instead of pieces of cork.

OCHUS, a king of Persia, son of Artaxerxes. He was cruel and avaricious; and in order to strengthen himself on his throne, he murdered all his brothers and sisters. His subjects revolted; but he reduced them to obedience, and added Egypt to his other dominions. Bagoas his favourite eunuch poisoned him for the insults he had offered to Apis the god of the Egyptians; and he gave his flesh to be eaten by cats, and made handles for knives with his bones. It seems to be not a little remarkable, that all those monsters who disgraced humanity by their crimes, and sunk themselves below the level of brutes, have met with condign punishment; and this in general seems true, whether we refer to ancient or modern times.—A man of Cyzicus, who was killed by the Argonauts.—A prince of Persia, who refused to visit his native country for fear of giving all the women each a piece of gold.—A river of India or of Bactriana.—A king of Persia: He exchanged this name for that of Darius Nothus. See PERSIA.

OCKHAM, OCCAM, or OCCHAM (William of), was a celebrated scholastic divine in the 14th century, of the order of Cordeliers. He was a native of England, and disciple to the famous Duns Scotus. He was head of the Nominalists; and acquired so much celebrity, as to be denominated the *Invincible Doctor*.

At the request of Michael de Cesena, general of his order, he became a party-man with Lewis of Raviera, who was an avowed enemy of the church of Rome; and he really wrote vigorously against pope John XXII. and his successors. Trithemius informs us, that he used to say to Lewis, "My Lord, let your sword defend me, and my pen shall be always ready to support you." He treated Charles and Clement in a book he wrote against them with gross scurrility.

This, however, was a bold, dangerous, and imprudent step, and cannot well be defended on any proper principle. The effect of it, as might be expected, was an accusation against him and Cesena. They were charged with maintaining, that neither Christ nor his apostles had any possessions at all, either in common or as private property. This doctrine gave rise to that pleasant question called the *bread of the Cordeliers*; and consisted in determining, whether the dominion of things consumed in the use, such as bread and wine, belonged to them, or only the simple use of them, without the dominion? Their rule not permitting them to have any thing as property, Pope Nicolas III. who had been of their order, devised a method to enrich them, without breaking their rule. To this end he made an ordinance, that they should have only the usufruct of the estates which should be given to them, and that the soil and fund of all such donations should

belong to the Roman church at large. By this means he gave them the possession of an almost infinite number of estates, in the name of the church of Rome: but on this account, Pope Nicolas's bull was revoked by John XXII. who condemned the use without the dominion, by his *Extravaganta ad Conditorem*. He also condemned, by another *Extravaganta cum inter*, the doctrine about the possession of estates by Christ and his apostles. Ockham and Cesena were also excommunicated, because they had departed from Avignon without the pope's licence, and had written against him. Ockham, however, was absolved, as is said, from this censure before he died, which was about the year 1347.

We have several pieces of his, which are written with considerable wit and subtilty. The reformed church sometimes makes use of his reasoning against the church of Rome. Melchior Goldast printed, in his treatise upon monarchy, 413 questions of Ockham. His works are mentioned by many authors.

OCKLEY (Simon), a learned orientalist, was born at Exeter in 1678, and educated at Queen's college, Cambridge, where he distinguished himself by his intense application to literature. At the usual time he took the degrees in arts, and that of bachelor in divinity; but marrying very young, was precluded from a fellowship in his college, and this occasioned his being afterwards involved in many difficulties. In 1705 he was presented to the vicarage of Swavesey in Cambridgeshire; and in 1711 he was chosen Arabic professor of the university. He was perfect master of the Arabic and other oriental tongues: the learned Reland said of him, "Vir, si quis alius harum literarum peritus." Afterwards, however, he had the misfortune to be confined for some time in Cambridge castle for debt. The above preferments, notwithstanding, he enjoyed till his death, which happened on the 9th of August 1720. He wrote, 1. *Introductio ad Linguas Orientales*. 2. The history of the present Jews throughout the world; translated from the Italian of Leo Modena, a Venetian rabbi. 3. The improvement of human reason, exhibited in the life of Hai Ebn Yokdhan, translated from the Arabic. 4. An account of South-west Barbary, containing what is most remarkable in the kingdoms of Fez and Morocco; written by a person who had been a slave there a considerable time, and translated from his manuscript. 5. The history of the Saracens, collected from the most authentic Arabic authors, in 2 vols 8vo. He was not only well skilled in the learned languages, but also in the modern, as French, Spanish, Italian, &c.

OCRA, a viscous vegetable substance well known in the West Indies, where it is used to thicken soup, and for other purposes.

OCRISIA (fab. hist.), the wife of Corniculus, was one of the attendants of Tanaquil the wife of Tarquinius Priscus. As she was throwing into the flames for offerings some of the meats that were served on the table of Tarquin, she suddenly saw, as is reported, in the fire what Ovid calls *obsceni forma virilis*. She informed the queen of it; and when by her command she had approached near it, she conceived a son who was named Servius Tullius, and was educated in the king's family. He afterwards succeeded to the vac-

Ockley
Ocrisia.

Otaeteris ^H *Octavia*. cant throne. Some suppose that Vulcan had assumed that form which was presented to the eyes of Ocrisia, and that this god was the father of the sixth king of Rome.

OCTAETERIS, a cycle or term of eight years, in the Grecian chronology, at the conclusion of which three entire lunar months were added. This cycle was in use till Meton's invention of the golden number or cycle of 19 years.

OCTAGON, or **OCTOGON**, in geometry, is a figure of eight sides and angles; and this, when all the sides and angles are equal, is called a *regular octagon*, or one that may be inscribed in a circle.

OCTAGON, in fortification, denotes a place that has eight bastions. See **FORTIFICATION**.

OCTAHEDRON, or **OCTAEDRON**, in geometry, one of the five regular bodies, consisting of eight equal and equilateral triangles.

OCTANDRIA (*οκτω* "eight," and *ανδρ* a "man, or husband,") the 8th class in Linnæus's sexual system; consisting of plants with hermaphrodite flowers, which are furnished with eight stamina, or male organs of generation. See **BOTANY**, p. 430.

OCTANT, or **OCTILE**, in astronomy, that aspect of two planets, wherein they are distant an eighth part of a circle, or 45° from each other.

OCTAPLA, in matters of sacred literature, denotes a polyglot bible, consisting of eight columns, and as many different versions of the sacred text; viz. the original Hebrew both in Hebrew and Greek characters, Greek versions, &c.

OCTATEUCH, an appellation given to the eight first books of the Old Testament.

OCTAVE, in music. See **INTERVAL**.

OCTAVIA, daughter of Caius Octavius and sister to Augustus Cæsar. See the following article. She was one of the most illustrious ladies of ancient Rome; her virtues and her beauty were equally conspicuous. Prideaux says she was much handsomer than Cleopatra. She married Claudius Marcellus, and after his death M. Antony. Her marriage with Antony was a political match, to reconcile her brother and him together. Antony proved for some time attentive to her; but when he had seen Cleopatra, he neglected and despised her; and when she attempted to withdraw him from this illegal amour by going to meet him at Athens, she was rebuked and totally banished from his presence. This affront was highly resented by her brother; and though Octavia endeavoured to pacify him by palliating Antony's behaviour, yet he resolved to revenge her cause by arms. After the battle of Actium and the death of Antony, Octavia, forgetful of her own injuries, took into her house all the children of her husband, and treated them with extraordinary tenderness. Marcellus, her son by her first husband, was married to a niece of Augustus, and openly intended as a successor to his uncle. His sudden death plunged all the family into the greatest grief. Virgil, whom Augustus patronized, undertook of himself to pay a melancholy tribute to the memory of a young man whom Rome had looked upon as her future father and patron. He was desired to repeat his composition in the presence of the emperor and his sister. Octavia burst into tears even when the

poet began; but when he mentioned *Tu Marcellus* *Octavia*, *eris*, she swooned away. This tender and pathetic encomium upon the merit and the virtues of young Marcellus she liberally rewarded, and Virgil received 10,000 sesterces, according to some L. 78 : 2 : 6, for every one of the verses. Octavia had two daughters by Antony, Antonia Major and Antonia Minor. The elder married L. Domitius Ahenobarbus, by whom she had Cn. Domitius, who was the father of the Emperor Nero by Agrippina the daughter of Germanicus. Antonia Minor, who was as virtuous and as beautiful as her mother, married Drusus the son of Tiberius, by whom she had Germanicus and Claudius, who reigned before Nero. The death of Marcellus constantly preyed upon the mind of Octavia, who died of grief or melancholy, about 11 years before the Christian era. Her brother paid great regard to her memory, and pronounced her funeral oration himself. The Roman people also showed their regard for her virtues, by wishing to pay her divine honours.—A daughter of the Emperor Claudius by Messalina. She was betrothed to Silanus, but by the intrigues of Agrippina, she was married to the Emperor Nero in the 16th year of her age. She was soon after divorced under pretence of barrenness; and the emperor married Poppæa, who exercised her enmity upon Octavia by procuring her to be banished into Campania. She was afterwards recalled by the people; but Poppæa, who was determined on her ruin, caused her again to be banished to an island, where she was ordered to kill herself by opening her veins. Her head was cut off and carried to Poppæa.

OCTAVIANUS, or **OCTAVIUS CÆSAR**, was nephew of Julius Cæsar the dictator, being the son of Accia his sister by Octavius a senator, and afterwards became the second emperor of Rome. He was born in the year of the city 691, during the consulship of Cicero. His uncle Julius Cæsar adopted him, and left him the greatest part of his fortune. When he was but 20 years of age, he was raised to the consulship. His youth and inexperience were ridiculed by his enemies; notwithstanding which obstacle, his prudence and valour raised his consequence. He made war against his opponents on pretence of avenging the assassination of his uncle. He engaged in five civil wars with great success, viz. The wars of Mutina, Perusia, Philippi, Sicily, and Actium: the first and last of which were against M. Antony; the second against L. Antony brother of the triumvir; the third was against Brutus and Cassius; and the fourth against Sext. Pompey, son of Pompey the Great. He united his forces with Antony's at the battle of Philippi; and had he not been supported by the activity and bravery of his colleague, he would doubtless have been totally ruined in that engagement. In his triumvirate with Antony and Lepidus, he obtained the western parts of the Roman empire; and, like his other colleagues, more firmly to establish his power, he proscribed his enemies and cut them off. The triumvirate lasted for 10 years. He had given his sister Octavia in marriage to Antony, to make their alliance more lasting; but when Cleopatra had charmed this unfortunate man, Octavia was repudiated. Augustus immediately took up arms to avenge the wrongs of his sister; but perhaps

more

Octavianus, more eagerly to remove a man whose power and ex-
October. istence kept him in continual fear and constant de-
 pendence. Both parties met at Actium to decide the fate of Rome. Antony was supported by all the power of the east, and Augustus by Italy. Cleopatra fled from the battle with 60 ships, and her flight ruined the interest of Antony, who followed her into Egypt. The conqueror soon after went into Egypt, likewise besieged Alexandria, and honoured with a magnificent funeral his unfortunate colleague and the celebrated queen, whom the fear of being led in the victor's triumph at Rome had driven to commit suicide. After he had established peace all over the world, he shut the gates of the temple of Janus, A. U. C. 753. He was twice determined to lay down the supreme power immediately after the victory obtained over Antony, and on account of his ill health; but his two faithful friends Mecænas and Agrippa dissuaded him, and contended, that if he did he would leave it to be the prey of the most powerful, and expose himself to the greatest dangers. He died at Nola in the 76th year of his age, after he had held the sovereign power for 57 years.—He was an active emperor, and consulted the good of the Romans with the greatest anxiety and care. He visited all the provinces except Africa and Sardinia, and his consummate prudence and experience occasioned many salutary laws. He is, however, accused of licentiousness and adultery; but the goodness of his heart, the fidelity of his friendship, and the many good qualities which the poets whom he patronized have perhaps truly celebrated, made some, though in the eye of strict religion and true morality but little, amends for his natural foibles. He was ambitious of being esteemed handsome; and as he was publicly reported to be the son of Apollo according to his mother's declaration, he wished his flatterers to represent him with the figure and attributes of that god. Like Apollo, his eyes were clear, and he affected to have it thought that they possessed some divine irradiation, and was well pleased if, when he fixed his eyes upon any body, they held down their eyes as if overcome by the glaring brightness of the sun. He distinguished himself by his learning; he was a complete master of the Greek language, and wrote some tragedies, besides memoirs of his life and other works, which are now lost. He married four times; but he was unhappy in all these connections; and his only daughter Julia disgraced herself and her father by the debauchery and licentiousness of her manners. He recommended at his death his adopted son Tiberius as his successor. He left his fortune partly to him and to Drusus, and made donations to the army and Roman people. The title of Augustus was conferred upon him by the senate after the battle of Actium and the final destruction of the Roman republic. The title continued afterwards, being given to his successors in the empire. Virgil is said to have written his *Æneid* at the desire of Augustus, whom he represents under the amiable and perfect character of *Æneas*. The name of Octavius was very common at Rome; it was the name of a variety of men of very considerable rank.

OCTOBER, in chronology, the eighth month of Romulus's year, which the name implies; but tenth

in the kalendar of Numa, Julius Cæsar, &c. The senate gave this month the name *Faustinus*, in compliment to Faustina, the wife of the Emperor Antoninus; Commodus would have it called *Invidus*; and Domitian named it *Domitianus*; but in spite of all these attempts it still retains its original name. This month was sacred to Mars, and under his protection.

OCTOBER Equus, a horse annually sacrificed to Mars in the month of October, either because the horse is a warlike animal, or to punish him for the taking of Troy. A race was run with chariots, drawn by two horses, previous to the sacrifices, and he that ran quickest was adjudged to be the victim.

OCTOSTYLE, in the ancient architecture, is the face of an edifice adorned with eight columns.

OCULUS, the EYE, in anatomy. See there, n° 142.

OCULUS Beli, in natural history, one of the semipellucid gems, of a greyish white colour, variegated with yellow and with a black central nucleus: it is of a roundish form, and its variegations very beautifully represent the pupil and iris of the eye; whence the name.

OCULUS Mundi, or *Lapis Mutabilis*. See **HYDROPHANES**.

OCULUS Cati. See **ASTERIA**.

OCYMOPHYLLON, in botany: a name given by Buxbaum to a new genus of plants, the characters of which are these: The flower is of the staminate kind, having no petals; this stands upon the embryo fruit, which afterwards becomes an oblong quadrangular seed-vessel, divided into four cells, and containing roundish and very small seeds; its leaves are like those of the common ocymum or basil, whence its name; and its place of growth is in damp marshes. Boccone has described it under the improper name of *glaux*, calling it the *great, green-flowered, marsh glaux*.

OCYMUM, BASIL; a genus of the gymnospermia order, belonging to the didynamia class of plants; and in the natural method ranking under the 42d order, *Verticillate*. The upper lip of the calyx is orbiculated, the inferior one quadrifid; the corolla is resupinated, with one lip quadrifid, the other undivided; the exterior filament sends out a reflected process at the base. There are eight species, all of them natives of warm climates, rising from six inches to two feet in height, and having a strong aromatic smell, resembling that of cloves. One of the species is used in the kitchen, particularly by the French cooks, who make great use of it in their soups and sauces. This rises about ten inches high, sending out branches by pairs opposite, from the bottom; the stalks and branches are four-cornered; the leaves are oval, spear-shaped, ending in acute points, and are indented on their edges; the whole plant is hairy, and has a strong scent of cloves too powerful for most persons, but to some it is very agreeable. These plants are propagated by seeds, and will thrive in this country in the open air, and will even ripen their seeds if placed in a stove or airy glass-case.

OCAKOW, or **OCAKOFF**, a town of Turkey in Europe, and capital of a Sangiack of the same name, inhabited by Tartars. During a late war, here was a Turkish garrison of 20,000 men. However, it was taken by the Russians in 1737, and all those that resisted were put to the sword. The Russians themselves lost

Oczakow 18,000 men in the assault. The Turks returned the same year with 70,000 men to retake it; but were obliged to retire, after the loss of 20,000. In 1738, the Russians withdrew their garrison, and demolished the fortifications. It is seated on the river Bog, to the west of the Nieper, or rather where they both unite and fall into the Black Sea. It is 42 miles south-west of Bialagrod, and 190 north by east of Constantinople. It has been lately a subject of great contest between the Russians and Turks. The affair is fresh in our readers memories; but the following more particular account of the place, will not, we trust, be unacceptable to our readers.—It is called by the Turks *Dzain Crimenda*, is seated at the mouth of the Nieper into the Black Sea, 120 miles from Bender, to the south-east. The river is here above a mile broad. Hither the Turkish galleys retire which guard the mouth of the river, to prevent the Cossacks from pirating upon the Black Sea. Here is no port, but good anchorage. It is defended by a castle, surrounded with walls 25 feet high; those of the town are much lower. There are about 2000 people at Oczakow. Below the castle are two towns or suburbs, situated on the declivity of a hill, which on the other side has nothing but precipices. To the south of these towns is another small castle, where is some artillery to prevent vessels from coming up the river. Here is also a tower, in which are always some Turks upon the watch to discover from afar any of the Cossacks at sea, and give notice of them to the galleys by a signal. The city is inhabited by Tartars though garrisoned by Turks. E. Long. 30. 50. N. Lat. 46. 50.

ODA, in the Turkish seraglio, signifies a class, order, or chamber. The grand signior's pages are divided into five classes or chambers. The first, which is the lowest in dignity, is called the *great oda*, from the greater number of persons that compose it; these are the juniors, who are taught to read, write, and speak the languages. The second is called the *little oda*, where from the age of 14 or 15 years, till about 20, they are trained up to arms, and the study of all the polite learning the Turks are acquainted with. The third chamber, called *kilar oda*, consists of 200 pages, which, besides their other exercises, are under the command of the *kilardgi-bachi*, and serve in the pantry and fruitery. The fourth consists only of 24, who are under the command of the *khazineda-bachi*, and have charge of the treasure in the grand signior's apartment, which they never enter with cloaths that have pockets. The fifth is called *kas oda* or *privy-chamber*; and is composed of only 40 pages who attend in the prince's chamber. Every night eight of these pages keep guard in the grand signior's bed chamber while he sleeps: they take care that the light, which is constantly kept in the room, does not glare in his eyes, lest it should awake him: and if they find him disturbed with troublesome dreams, they cause him to be awaked by one of their agas.

ODA-Bachi, or *Oddabassi*, an officer in the Turkish soldiery, equivalent to a serjeant or corporal among us. The common soldiers and janizaries, called *oldachis*, after having served a certain term of years, are always preferred and made *biquelairs*; and of *biquelairs* in time become *odobachis*, i. e. corporals of companies,

or chiefs of certain divisions, whose number is not fixed; being sometimes ten, and sometimes twenty.

Their pay is six doubles *per* month; and they are distinguished by a large felt, a foot broad and above a foot long, hanging on the back, with two long ostrich feathers.

ODE, in poetry, a song, or composition proper to be sung. See POETRY.

ODED, a prophet of the Lord, who being at Samaria, when the Israelites of the ten tribes returned from the war, with their king Pekah, together with 200,000 of the people of Judah captives, he went out to meet them, and said, "You have seen that the Lord God of your fathers was in wrath against Judah; he has therefore delivered them into your hands, and you have slain them inhumanly, so that your cruelty has ascended up into heaven; and more than this, you would make slaves of the children of Judah, who are your brethren, and would add this sin to the many others you have committed: therefore, hear the counsel that I give you; send back these captives, lest the Lord should pour out his fury upon you." Oded having done speaking, some of the chiefs of Samaria seconded him, and by their remonstrances prevailed with the Israelites to set the captives at liberty (2 Chron. xxviii.) See AHAS.

The enlargement of the captives being obtained, the principal men of Samaria took care of them, gave them cloaths and food and other necessary assistances. After which they furnished them with horses, because the greatest part of them were so tired and exhausted that they were not able to walk. Thus they conducted them to Jericho, which was in the confines of the land of Judah. This is all that is come to our knowledge concerning the prophet Oded.

ODENSEE, the capital of the isle of Funen, a place of such high antiquity, that some Danish writers derive its foundation and name from Oden, the god and hero of the Gothic nations. "Its name certainly occurs (says Mr Coxe) in the earliest ages of the Danish history; and it was a town of great note long before Copenhagen existed. Odenfee stands upon a small river, not navigable, and about two miles from the bay of Stegestrand. Many of the houses are ancient, bearing dates about the middle of the 16th century; but part is newly built: it contains about 5200 inhabitants, who carry on some commerce, exporting chiefly grain and leather; the latter is much esteemed, and its goodness is supposed to arise from a certain property in the river water, in which it is soaked for tanning. The Danish cavalry are supplied from thence with the greatest part of their leathern accoutrements.

"Odenfee is the seat of a bishop, which was founded by Harald Blaaland in 980, and is the richest in Denmark next to Copenhagen. It has a school, endowed by the celebrated Margaret of Valdemar, in which a certain number of scholars, from six to 16 years of age, are instructed gratis: they live and board in the town, and each receives a yearly pension; other scholarships have been also founded by private persons. The whole number amounted to 70. There is also a gymnasium, instituted by Christian IV. for the admission of students at the age of 16. This seminary

was

Ode
||
Odenfee.

Odenatus

Odin.

was still further improved by the liberality of Holberg the Danish historian, who protected letters with the same zeal with which he cultivated them. It is now greatly fallen from its former flourishing state, containing, when I passed through the town, only eight students. The cathedral is a large old brick building, which has nothing remarkable except some costly monuments of a private Danish family. The church, which formerly belonged to the convent of Recolets, contains the sepulchre of John king of Denmark, and of his son Christian II." E. Long. 10. 27. N. Lat. 55. 28.

ODENATUS, a celebrated prince of Palmyra. He very early inured himself to bear fatigues, and by hunting leopards and wild beasts, accustomed himself to the labours of a military life. He was a faithful friend to the Romans; and when Aurelian had been taken prisoner by Sapor king of Persia, Odenatus warmly interested himself in his cause, and solicited his release, by writing to the conqueror, and by sending him presents. The king of Persia was offended at this liberty of Odenatus, he tore the letter, and ordered the presents that were offered to be thrown into a river; and in order to punish Odenatus, who had the impudence, as he called it, to pay homage to so great a monarch as himself, he commanded him to appear before him, on pain of being devoted to instant destruction with all his family, if he dared to refuse. Odenatus despised this haughty summons of Sapor, and opposed force by force. He obtained some considerable advantages over the troops of the Persian king and took his wife prisoner, with a great and rich booty. These services were observed with gratitude by the Romans; and Gallienus, the then emperor, named Odenatus as his colleague on the throne, and gave the title of *Augustus* to his children and to his wife the celebrated Zenobia. Odenatus invested with new power, resolved to signalise himself more conspicuously by conquering the barbarians of the north: but his exulting was of short duration; he perished by the dagger of one of his own relations, whom he had slightly offended at a domestic entertainment. He died at Emessa about the 267th year of the Christian era. Zenobia succeeded to his titles and honours.

ODER, a river of Germany, which has its source near a town of the same name in Silesia, and on the confines of Moravia. It runs north through that province, and then into the Marche of Brandenburg and Pomerania, where it forms a large lake, afterwards falling into the Baltic Sea by three mouths; between which lie the islands Usedom and Wolin. It passes by several towns; as Ratibor, Oppelen, Breslau, Glogau, and Crossen, in Silesia; Francfort, Lebus, and Custrin, in Brandenburg; and Gartz, Stetin, Cammin, Wallin, Usedom, and Wolgast, in Pomerania.

ODEUM, in Grecian antiquity, a music-theatre, built by Pericles; the inside of which was filled with seats and ranges of pillars, and on the outside the roof descended shelving downwards from a point in the centre, with many bendings, in imitation of the king of Persia's pavilion. Here the musical prizes were contended for; and here also, according to Aristophanes, was a tribunal.

ODIN (see FREA), in mythology, called also in N° 245.

the dialect of the Anglo-Saxons *Woden* or *Wodan*, a name given by the ancient Scythians to their supreme god, and assumed, about 70 years before the Christian era, by Sigge, a Scythian prince, who conquered the northern nations, made great changes in their government, manners, and religion, enjoyed great honours, and had even divine honours paid him. According to the account given of this conqueror by Snorro, the ancient historian of Norway, and his commentator Torfæus, Odin was a Scythian, who withdrew himself, with many others in his train, by flight, from the vengeance of the Romans, under the conduct of Pompey; and having officiated as priest in his own country, he assumed the direction of the religious worship, as well as the civil government, of the nations which he conquered. Having subdued Denmark, Sweden, and Norway, he retired to Sweden, where he died. There is nothing certain in this account; but it is probable, that the god, whose prophet or priest this Scythian pretended to be, was named *Odin*, and that the ignorance of succeeding ages confounded the Deity with his priest, composing out of the attributes of the one, and the history of the other, the character of the northern conqueror. He deluded the people by his enchantments and skill in magic: having cut off the head of one Mimer, who in his lifetime was in great reputation for wisdom, he caused it to be embalmed, and persuaded the Scandinavians that he had restored it to the use of speech; and he caused it to pronounce whatever oracles he wanted. The Icelandic chronicles represent Odin as the most eloquent and persuasive of men; they ascribe to him the introduction of the art of poetry among the Scandinavians, and likewise the invention of the Runic characters. He had also the address to persuade his followers, that he could run over the world in the twinkling of an eye; that he had the direction of the air and tempests; that he could transform himself into all sorts of shapes, could raise the dead, could foretel things to come, deprive his enemies, by enchantment, of health and vigour, and discover all the treasures concealed in the earth. They add, that by his tender and melodious airs, he could make the plains and mountains open and expand with delight; and that the ghosts, thus attracted, would leave their infernal caverns, and stand motionless about him. Nor was he less dreadful and furious in battle; changing himself into the shape of a bear, a wild bull, or a lion, and amidst ranks of enemies committing the most horrible devastation, without receiving any wound himself.

Dr Henry gives this account of him: "Odin is believed to have been the name of the one true God among the first colonies who came from the east and peopled Germany and Scandinavia, and among their posterity for several ages. But at length a mighty conqueror, the leader of a new army of adventurers from the east, over-run the north of Europe, erected a great empire, assumed the name of *Odin*, and claimed the honours which had been formerly paid to that deity. From thenceforward this deified mortal, under the name of *Odin* or *Wodin*, became the chief object of the idolatrous worship of the Saxons and Danes in this island, as well as of many other nations. Having been a mighty and successful warrior, he was believed to be the god of war, who gave victory, and revived

Odin.

Henry's
Hist of Brit-
tain, vol. ii.

Odin revived courage in the conflict. Having civilized, in some measure, the countries which he conquered, and introduced arts formerly unknown, he was also worshipped as the god of arts and artists. In a word, to this Odin his deluded worshippers impiously ascribed all the attributes which belong only to the true God: to him they built magnificent temples, offered many sacrifices, and consecrated the fourth day of the week, which is still called by his name in England and in all the other countries where he was formerly worshipped. Notwithstanding all this, the founders of all the kingdoms of the Anglo-Saxon heptarchy pretended to be descended from Wodin, and some of them at the distance only of a few generations."

ODIN'S FIRE. We have this account of it in Gough's Camden. "In Evie parish, in the Orkneys, near the sea, are some rocks, which frequently in the night appear on fire; and the church of St Michael there was often seen full of lights, called fires sent by Odin to guard their tombs, but now ceased. This may be a meteor, or some inflammable matter on the cliffs, as at Charmouth Dorset."

ODINUS, a celebrated hero of antiquity, who flourished about 70 years before the Christian era, in the northern parts of ancient Germany, or in the modern kingdom of Denmark. He was at the same time a priest, a soldier, a poet, a monarch, and a victor. He imposed upon the credulity of his superstitious countrymen, and made them believe that he could raise the dead, and that he was acquainted with futurity. When he had extended his power, and increased his fame by conquest and by artifice, he determined to die in a different way from other men. He assembled his friends, and with the sharp point of a lance he made in his body nine different wounds in the form of a circle; and when expiring he declared that he was going to Scythia, where he should become an immortal god. He added, that he would prepare bliss and felicity for those of his countrymen who lived a virtuous life, who fought with bravery, and who died like heroes in the field of battle. These injunctions had the wished-for effect: his countrymen superstitiously believed him, and constantly recommended themselves to his protection when they engaged in battle; and they entreated him to receive the souls of such as fell in war.

De Odio et Atia. See *False Imprisonment*.

The writ *de odio et atia* was anciently used to be directed to the sheriff, commanding him to inquire whether a prisoner charged with murder was committed upon just cause of suspicion, or merely *propter odium et atiam*, for hatred and ill-will; and if upon the inquisition due cause of suspicion did not then appear, then there issued another writ for the sheriff to admit him to bail. This writ, according to Bracton, ought not to be denied to any man; it being expressly ordered to be made out *gratis*, without any denial, by *magna charta*, c. 26. and statute Westm. 2. 13 Edw. 1. c. 29. But the statute of Gloucester, 6 Edw. 1. c. 9. restrained it in the case of killing by misadventure or self-defence, and the statute 28 Edw. III. c. 9. abolished it in all cases whatsoever: but as the stat. 42 Ed. III. c. 1. repealed all statutes then in being, contrary to the great charter, Sir Edward Coke is of opinion that the writ *de odio et atia* was thereby revived. See *HABEAS Corpus*.

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ODO (St), second abbot of Clugni in France, was illustrious for learning and piety in the 10th century. The sanctity of his life contributed greatly to enlarge the congregation of Clugni; and he was so esteemed, that popes, bishops, and secular princes, usually chose him the arbiter of their disputes. He died about the year 942, and his works are printed in the Bibliotheca of Clugni.

Odo Cantianus, so called as being a native of Kent in England, was a Benedictine monk in the 12th century, in which order his learning and eloquence raised him to the dignity of prior and abbot. Archbishop Becket was his friend; and his panegyric was made by John of Salisbury. He composed Commentaries on the Pentateuch, and the Second Book of Kings; Moral Reflections on the Psalms; treatises intitled, *De onere Philistin*; *De moribus Ecclesiasticis*; *De vitiis et virtutibus Animæ*, &c.

ODOACER, according to Ennodius, was meanly born, and only a private man in the guards of the emperor Augustulus, when (A. D. 476, under the consulship of Basiliscus and Armatus) the barbarians chose him for their leader. The barbarians thought, as they often defended Italy, they had a right at least to part of it; but upon demanding it they were refused, and the consequence was a revolt. Odoacer is said to have been a man of uncommon parts, capable alike of commanding an army or governing a state. Having left his own country when he was very young, to serve in Italy, as he was of a stature remarkably tall, he was admitted among the emperor's guards, and continued in that station till the above year; when, putting himself at the head of the barbarians in the Roman pay, who, though of different nations, had unanimously chosen him for their leader, he marched against Orestes, and his son Augustulus, who still refused to share any of the lands in Italy. The Romans were inferior both in numbers and valour, and were easily conquered: Orestes was ordered to be slain; but the emperor Augustulus was spared, and, though stripped of his dignity, was treated with humanity, and allowed a liberal sum for his own support and for that of his relations. Odoacer was proclaimed king of Italy; but assumed neither the purple nor any other mark of imperial consequence. He was afterwards defeated and slain by Theodoric the Ostrogoth. See *OSTROGOTH*.

ODONTALGIA, the TOOTHACH. See *MEDICINE*, n° 210 and 411.

ODONTOIDE, in anatomy, an appellation given to the process of the second vertebra of the neck, from its resemblance to a tooth.

ODOROUS, or **ODORIFEROUS**, appellations given to whatever smells strongly, whether they be fetid or agreeable; but chiefly to things whose smell is brisk and pleasant.

ODYSSEY, the name of an epic poem composed by Homer, which, when compared with the Iliad, exhibits its author as the setting sun, whose grandeur remains without the heat of his meridian beams.

The poet's design in the Odysey was to paint the miseries of a kingdom in the absence of its supreme governor, and the evil consequences resulting from a disregard of law, and of that subordination without which society cannot exist. With this view he sets

A a

before

Odo
Odysey.

Odyssey.
||
Oedemz.

before his countrymen the adventures of a prince who had been obliged to forsake his native country, and to head an army of his subjects in a foreign expedition; and he artfully contrives, without interrupting the narrative, to make the reader acquainted with the state of the country in the absence of its sovereign. The chief having gloriously finished the enterprise in which he was engaged, was returning with his army; but in spite of all his eagerness to be at home, he was detained on the way by tempests for several years, and cast upon several countries differing from each other in manners and in government. In these dangers his companions, not strictly obeying his orders, perish through their own fault. In the mean time the grandees of his country abuse the freedom which his absence gave them; consume his estate; conspire to destroy his son; endeavour to compel his queen to accept one of them for her husband; and indulge themselves in every species of violence, from a persuasion that he would never return. In this they were disappointed. He returns; and discovering himself only to his son and some others who had maintained their allegiance, he is an eye-witness of the insolence of his enemies, punishes them according to their deserts, and restores to his island that tranquillity and repose to which it had been a stranger during the many years of his absence.

† Blair's
Lectures.

Such is the fable of the Odyssey, in which there is no opportunity of displaying that vigour and sublimity which characterise the Iliad. "It descends from the dignity of gods and heroes†, and warlike achievements; but in recompence we have more pleasing pictures of ancient manners. Instead of that ferocity which reigns in the other poem, this presents us with the most amiable images of hospitality and humanity; entertains us with many a wonderful adventure; and instructs us by such a constant vein of morality and virtue which runs through the poem," sometimes in precepts, and always in the conduct of the hero, that we should not wonder if Greece, which gave the appellation of *wise* to men who uttered single sentences of truth, had given to Homer the title of *the father of virtue*, for introducing into his work such a number of moral maxims. As a poem, however, the Odyssey has its faults. The last twelve books are tedious and languid; and we are disappointed by the calm behaviour of Penelope upon the discovery of her long lost husband.

OECONOMICS, the art of managing the affairs of a family or community; and hence the person who takes care of the revenues and other affairs of churches, monasteries, and the like, is termed *conomus*.

OECONOMY, denotes the prudent conduct, or discreet and frugal management, whether of a man's own estate or that of another.

† See Gene-
ration, Nu-
trition, &c.

Animal OECONOMY, comprehends the various operations of nature in the generation, nutrition, and preservation of animals†. The doctrine of the animal œconomy is nearly connected with physiology, which explains the several parts of the human body, their structure, use, &c. See ANATOMY and MEDICINE.

OECUMENICAL, signifies the same with *general* or *universal*; as, œcumenical council, bishop, &c.

OEDEMA, or PHLEGMATIC TUMOUR, in medicine and surgery, a sort of tumour attended with pale-

ness and cold, yielding little resistance, retaining the print of the finger when pressed with it, and accompanied with little or no pain.

This tumour obtains no certain situation in any particular part of the body, since the head, eye-lids, hands, and sometimes part, sometimes the whole body, is afflicted with it. When the last mentioned is the case, the patient is said to be troubled with a cachexy, leucophlegmatia, or dropsy. But if any particular part is more subject to this disorder than another, it is certainly the feet, which are at that time called *swelled* or *œdematous feet*.

OEDERA, in botany: A genus of the polygamia segregata order, belonging to the syngenesia class of plants. The calyces are multiflorous; the corollas tubular, hermaphrodite, and one or two feminine ones ligulate; the receptacle is chaffy; the pappus with numerous chaff.

OEDIPUS, the unfortunate king of Thebes, whose history is partly fabulous, flourished about 1266 B. C. It is said he was given by his father to a shepherd, who was ordered to put him to death, in order to prevent the misfortunes with which he was threatened by an oracle. But the shepherd, being unwilling to kill him with his own hands, tied him by the feet to a tree, that he might be devoured by wild beasts. The infant was however found in this situation by another shepherd named *Phorbas*, who carried him to Polybus king of Corinth; where the queen, having no children, educated him with as much care as if he had been her own son. When he was grown up, he was informed that he was not the son of Polybus: on which, by order of the oracle, he went to seek for his father in Phocis; but scarce was he arrived in that country, when he met his father on the road, and killed him without knowing him. A short time after, having delivered the country from the monster called the *Sphinx*, he married Jocasta, without knowing that she was his mother, and had four children by her; but afterwards, being informed of his incest, he quitted the throne, and, thinking himself unworthy of the light, put out his eyes. Eteocles and Polynices, who were celebrated amongst the Greeks, were born of this incestuous marriage.

OEGWA, a town on the gold coast of Africa, standing, according to Artus, on the brow of an eminence, raising itself by a gentle ascent to a considerable height, and defended by rocks, against which the waves beat with the utmost violence, the noise of which is heard at a great distance.

Barbot affirms, that Oegwa contains above 500 houses, disjoined by narrow crooked streets; and that from the sea it has the appearance of an amphitheatre. Des Marchais reduces the number of houses to 200, in the centre of which stands a large square building, the repository of their gold-dust and other commodities. The houses are built of earth and clay, but convenient, and well furnished with chairs, stools, mats, carpets, earthen pots, and even looking-glasses, which last they purchase from the Europeans. No part of the coast is better provided with all kinds of eatables, which are sent in from the adjacent cantons, and sold in public markets. Every thing is bought and sold with gold-dust, which is the standard of all other commodities, and brought hither in great abundance.

Oedera
||
Oegwa.

Oeland, and Mandingo. The gold is sold by weight, and the quantity determined by nice scales, made in the country before it was frequented by the Europeans: a proof that those negroes are not wholly ignorant of the more refined principles of mechanics. Next to gold, the chief commerce of the place consists in the sale of fish, of which they catch prodigious quantities on the coast. Although the natives are brave and warlike, yet in time of peace no people are more industrious, their whole time being employed in catching fish or cultivating the fruits of the earth. They are extremely expert in throwing the line, and fishing by the hook; nor is their intrepidity in combating the elements, and pursuing their employments in all kinds of weather, less astonishing. Every day in the week, except Wednesday, which is sacred to the Fetiche, they employ in their several occupations, and no season of the year is exempted from fishing. Their canoes weather storms which would endanger the largest shipping; and the negroes have the dexterity of making their advantage of those seasons, which oblige others to discontinue their labours, by throwing their lines with the same success in tempestuous as in calm weather.

OELAND, an island of Sweden, seated on the Baltic sea, between the continent of Gothland and the isle of Gothland. It lies between 56° and 57° of north latitude, and between 17° and 18° of east longitude. It is about 60 miles in length, and 15 in breadth; having a wholesome air, and a fertile soil, with rising hills, and several castles. It has no town of any great note.

OENANTHE, WATER DROPWORT: A genus of the digynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 45th order, *Umbellatae*. The florets are difform; those of the disc sessile and barren; the fruit crowned with the calyx. There are five species; of which the most remarkable is the *crocata*, or hemlock dropwort, growing frequently on the banks of ditches, rivers, and lakes, in many parts of Britain. The root and leaves of this plant are a strong poison; several persons have perished by eating it through mistake, either for water-parsnips or for celery, which last it resembles pretty much in its leaves. So exceedingly deleterious is this plant, that Mr Lightfoot tells us he has heard the late Mr Christopher d'Ehret, the celebrated botanic painter, say, that while he was drawing it, the smell or effluvia only rendered him so giddy, that he was several times obliged to quit the room, and walk out in the fresh air to recover himself; but recollecting at last what might be the probable cause of his repeated illness, he opened the door and windows of the room, and the free air then enabled him to finish his work without any more returns of the giddiness. Mr Lightfoot informs us, that he has given a spoonful of the juice of this plant to a dog, but without any other effect than that of making him very sick and stupid. In about an hour he recovered; and our author has seen a goat eat it with impunity. To such of the human species as have unfortunately eat any part of this plant, a vomit is the most approved remedy.

Lobel calls this vegetable *enanthe aquatica cicutæ fa-*

cic. It grows in great plenty all over Pembrokehire, and is called by the inhabitants *five-fingered root*: it is much used by them in cataplasms for the felon or worst kind of whitlow. They eat some parts of it, but carefully avoid the roots or stalk. These indeed are of a most pernicious nature, and never fail to prove instantly fatal, unless a proper remedy is applied. The following instance, in addition to what has been said, of the effects of this plant on man, is given in the Gentleman's Magazine for July 1747.

Three French prisoners being in the fields near the town of Pembroke, dug up a large quantity of a plant with its roots (which they took to be wild celery) to eat with their bread and butter for dinner. After washing it, while yet in the fields, they all three eat, or rather only tasted, of the roots.

As they were entering the town, one of them was seized with convulsions. The other two ran and sent a surgeon, who endeavoured first to bleed, and then vomit him; but in vain, and he died presently.

Ignorant of the cause of their comrade's death, and of their own danger, they gave of these roots to eight other prisoners, who all eat some of them with their dinner.

A few minutes after, the two who gathered the plants were seized in the same manner as the first; of which one died: The other was bled, and an emetic with great difficulty forced down, on account of his jaws being set. This operating, he recovered; but was some time much affected with a dizziness in his head, though not sick, or in the least disordered in his stomach. The other eight, being bled and vomited immediately, were soon well.

This vegetable is so extremely like celery, and therefore, as in the above case, so apt to be mistaken for it, that it cannot be enough guarded against by all who have a proper regard for themselves. In the plate (see Plate CCCXLVII.), X is the shape of the root. *a*, The part cut off from the stalk. *b*, A branch taken from the bottom of the stalk, where the leaves are largest. *c*, A top branch with the umbels of flowers. *d*, An anterior view of the flower in its natural size. *e*, A posterior view of the same. *f*, The anterior appearance of the flower through a microscope. *g*, The posterior view of the same. *h*, A view of the rudiments of the fruit after the decay of the flower. *i*, The same magnified. A* The shape of a leaf of *celery*. B, A leaf of parsley.—These two are printed, to prevent any unhappy mistake in eating the poisonous plant instead of either. We have added to the figures of this dangerous plant these leaves of celery and parsley, which, as we have said, it greatly resembles, in order to show our readers how careful they ought to be in case of an accident because of this similarity.

OENKJE, in botany, a species of iris. See IRIS.

OENOPTÆ, in Grecian antiquity, a kind of censors at Athens, who regulated entertainments, and took care that none drank too much, nor too little.

OENOS, in ornithology, the name used by authors for the stock-dove, or wood-pigeon, called also by some *vinago*, somewhat larger than the common pigeon, but of the same shape and general colour. Its neck is of a fine changeable hue, as differently opposed to the light; and its breast, shoulders, and wings, are of

Oenanthe
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Oenos.

Oenothera, a fine purplish hue, or red wine colour, from whence it has its name *vinago*. Its legs are red, and feathered a little below the joint.

OENOTHERA, TREE-PRIMROSE: A genus of the monogynia order, belonging to the octandria class of plants; and in the natural method ranking under the 17th order, *Calycanthemæ*. The calyx is quadri-fid; the petals four; the capsule cylindric beneath; the seeds naked. There are seven species; the most remarkable of which are,

1. The biennis, or common biennial tree-primrose. It hath a long, thick, deeply-striking root; crowned with many large, oval, spear-shaped, plane, spreading leaves; upright, thick, firm, rough, hairy stems, rising three or four feet high; garnished with long, narrow, lanceolate, close-fitting leaves, irregularly; and at all the axillas, from the middle upwards, large bright-yellow flowers.

2. Octovalvis, or octovalved, smooth, biennial tree-primrose, hath upright, firm, somewhat hairy stems, rising a yard high; oblong, spear-shaped, pointed, plane, smooth leaves; and at the axillas large bright-yellow flowers.

3. The fruticosa, or shrubby, narrow-leaved, perennial tree primrose, hath long thick roots; upright under-shrubby like red stems, two or three feet high; spear-shaped, lightly-indented leaves; and at the axillas pedunculated clusters of yellow flowers, succeeded by pedicellated, acute-angled capsules.

4. The pumila, or low perennial tree-primrose, hath fibrous roots, crowned with many oval, spear-shaped, close-fitting leaves; slender herbaceous stems from 10 to 12 inches long; garnished with spear-shaped, blunt, smooth leaves, having very short foot-stalks; and at the axillas smallish bright yellow flowers, succeeded by acute-angled capsules.

All these plants flower very profusely in June and July, coming out almost half the length of the stalks from the axillas; and as the stalk advances in stature new flowers are produced, succeeding those below; in which order the plants continue flowering from about midsummer till October: each flower is moderately large and conspicuous, consisting of four plane petals, which with the calyx forms a very long tube below, and spreading above, generally expand most towards the evening; and are succeeded by plenty of seed in autumn for propagation.

These plants are exotics from America; but are all very hardy, prosper in any common soil and situation, and have been long in the English gardens, especially the three first sorts; but the *œnothéra* biennis is the most commonly known.

The first and second species are biennial, and the third and fourth are perennial in root.

They are proper to be employed as plants of ornament for embellishing the pleasure-garden; they may be placed anywhere, and will effect a very agreeable variety three or four months with their plentiful blow of flowers.

The biennial kinds must be raised annually from seed, for they totally perish after they have flowered. But the perennials, once raised, continue for years by the root.

The propagation of all the sorts is by seed, and the perennial also by parting the roots.

OENOTRIA, an ancient name of Italy; so called from the *Oenotri*, (Virgil); inhabiting between Paestum and Tarentum, (Ovid). Originally Arcadians, (Dionysius Halicarnassæus), who came under the conduct of Oenotrus son of Lycaon, 17 generations before the war of Troy, or 459 years, at 27 years each generation, and gave name to the people. Cato derives the name from *Oenotrus*, king of the Sabines and Etruscans; but Varro from *Oenotrus*, king of the Latins; and Servius from the Greek name for wine, for which Italy was famous; of which opinion is Strabo.

OENOTRIDES (Strabo, Pliny), two small islands in the Tuscan sea, over-against Velia, a town of Lucania, called *Pontia* and *Ischia*; now *Penza* and *Ischia*, on the coast of the Principato Citra, or to the west of Naples. So called from the *Oenotri*, an ancient people of Italy.

OESSEL, an island of the Baltic sea, at the entrance of the gulf of Livonia. It is about 70 miles in length, and 50 in breadth, and contains 10 parishes. It is defended by the fortresses of Aïrensburg and Sonneburg. It lies between 22° and 24° of east longitude, and between 58° and 59° of north latitude.

OESOPHAGUS, in anatomy, the *GULA*, or *Gullet*, is a membranaceous canal, reaching from the fauces to the stomach, and conveying into it the food taken in at the mouth. See *ANATOMY*, n° 92.

OESTRUS, in zoology, a genus of insects belonging to the order of diptera. It has no mouth; but three punctures, without trunk or beak: Antennæ taper, proceeding from a lenticular joint. There are five species. Plate CCCL

1. *Bovis*, the breeze or gad-fly.—Thorax yellow, with a black transverse line between the wings: Abdomen tawny, with fine black transverse lines; last segment black: Wings white, with a brown transverse line, and three brown spots. Size of the large blue fly. Deposits its eggs under the skin on the backs of oxen, where the maggots are nourished the whole winter till the month of June; and plague the cattle so all the summer, that they are obliged to fly for refuge into the water, and dare not quit it the whole day.

2. *The hæmorrhoidalis*.—Body long, black, covered with tawny hair; middle of the thorax less hairy; wings immaculate; antennæ very short: Length half an inch. Deposits its eggs in the rectum of horses, and occasions great torment. See *BORRS*.

3. *Ovis*, the grey fly.—Spotted with black; front pale-yellow; legs brownish; wings with short black veins: length half an inch. Breeds in the frontal sinus of sheep; where the maggots, hatched from the eggs, lodge the whole winter, vellicating the internal membranes, and often bringing on death.

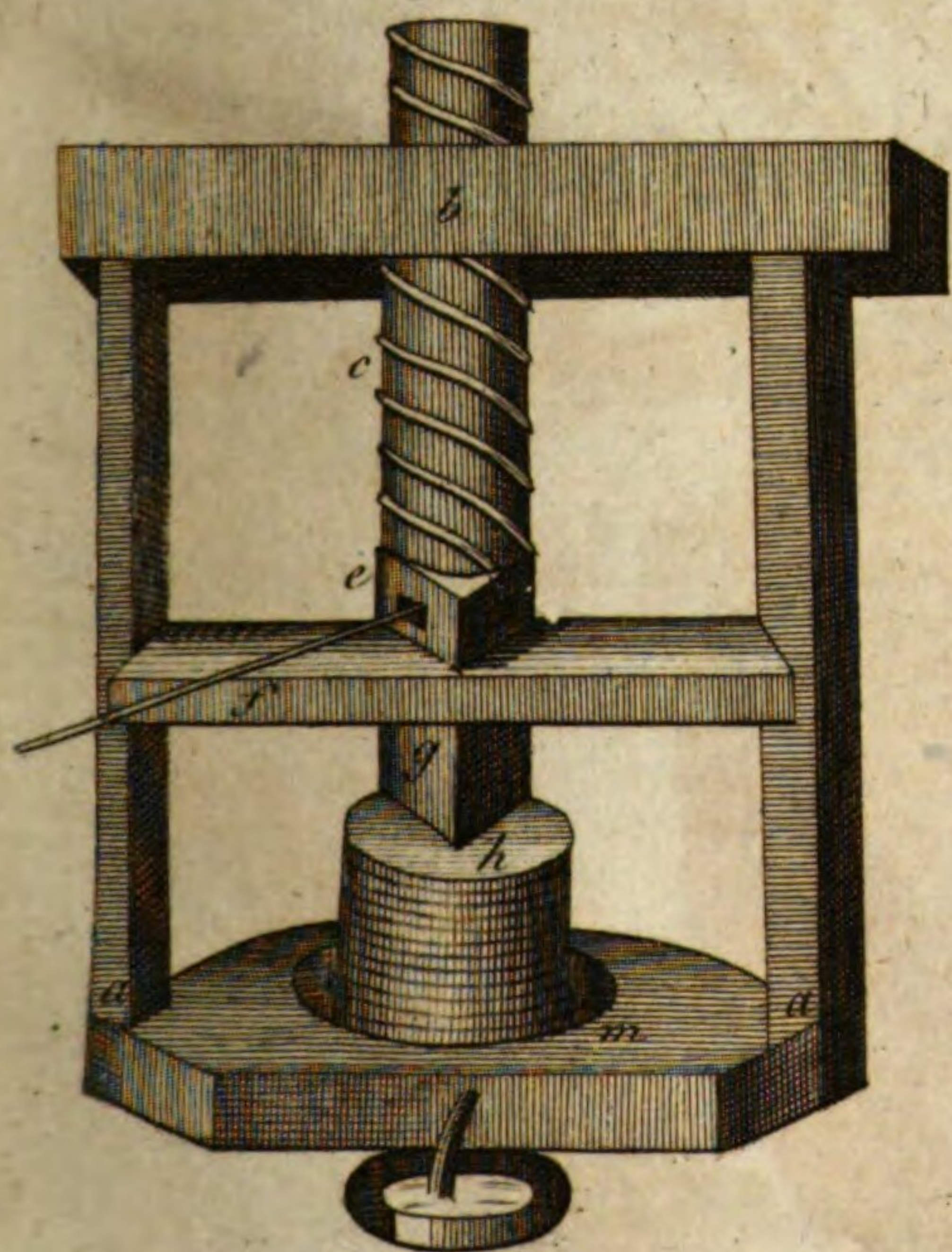
5. *The nasalis*.—Body black; but the head, thorax, and abdomen, covered with pale-red hair, except the first segment of the latter, which is covered with white hair; the wings immaculate. Breeds in the fauces of horses, entering by their nose.

5. *The tarandi*.—Thorax yellow; with a black line between the wings, which are immaculate: Abdomen tawny, last segment black. Infest the back of the rein-deer, so as greatly to retard the breed. The rein-deer of Lapland are obliged every year to fly to the Alpine mountains, to escape the pursuit of these insects.

Cenanthus, or Water Drop-wort.



Olive Press.



The Nut Cracker.



Spotted, or Surinam Nuthatch.



Nyl-Ghau.





Sharp tailed Oriole.



Oestrius.



Baltimore Oriole



Oceloxochitl.



A. Bell Prin. W. L. Sculptor fecit.

Oestrus.
||
Oeting.

insects: yet a fourth part of their number perish by them at two years old; the rest are emaciated, and have their skins spoiled. It is one of the most curious genera of insects. They are distinguished into several species, by reason of the different places wherein they deposit their eggs. Some, instructed by nature that their eggs cannot be hatched but under the skins of living creatures, such as bulls, cows, rein-deer, stags, and camels, fix upon them at the instant of laying their eggs. From the hinder part of their body issues a whimble of wonderful structure. It is a scaly cylinder, composed of four tubes, which draw out like the pieces of a spying-glass; the last is armed with three hooks, and is the gimblet with which the œstri bore through the tough hides of horned cattle. The animal seems to experience no pain from the puncture, unless the insect, plunging too deep, attacks some nervous fibre; in which case, the beast runs about, and becomes furious. The eggs being hatched, the grub feeds on the matter of the wound. The place of its abode forms upon the body of the quadrupeds a bunch sometimes above an inch high. When full-grown, the larva breaks through the tumor, and slides down to the ground; for doing which it takes the cool of the morning, that it may neither be overpowered by the heat of the day, nor chilled by the cold of the night: it then digs itself a burrow, into which it retires. Its skin grows hard, and turns to a very solid shell. There it is transformed to a chrysalis, and afterwards to a winged insect. Nature has provided for every exigence: the shell wherein the œstrus is inclosed, is of so strong a texture that it could not make its way out, if at one of the ends there were not a small valve, fastened only by a very slight filament. The first push the œstrus makes, the door gives way and the prison opens. The insect wings its way to woods and places frequented by cattle.

OETA (anc. geog.), a mountain of Thessaly, extending from Thermopylæ westward to the Sinus Ambracius, and in some measure cutting at right angles the mountainous country stretching out between Parnassus to the south, and Pindus to the north. At Thermopylæ it is very rough and high, rising and ending in sharp and steep rocks, affording a narrow passage between it and the sea from Thessaly to Locris (Strabo), with two paths over it; the one above Trachis, very steep and high; the other through the country of the Ænians, much easier and readier for travellers; by this it was that Leonidas was attacked in rear by the Persians (Pausanias). Here Hercules laid himself on the funeral pile (Silius Italicus, Ovid); the spot thence called *Pyra* (Livy), who says, that the extreme mountains to the east are called *Oeta*; and hence the poets allege, that day, night, sun, and stars, arose from *Oeta* (Seneca, Statius, Silius Italicus, Catullus, Virgil's *Culex*)—circumstances which show the height of this mountain.

OETING, a town of Germany, in Upper Bavaria, under the jurisdiction of Burkhausen. It is divided into the upper and the lower town, and seated on the river Inn, eight miles west of Burkhausen. E. Long. 12. 47. N. Lat. 48. 0. There is a great resort of pilgrims to the old chapel.

OETING, or *Oetingen*, a town of Germany, in the circle of Suabia, and capital of a county of the same

name, seated on the river Wurnitz. E. Long. 10. 45. N. Lat. 48. 52.

OETING, a county of Germany, in the circle of Suabia, bounded on the north and east by Franconia; on the south by the duchy of Neuburg; and on the west by that of Wirtemberg. It is about 40 miles from east to west, and 20 from north to south.

OFFA'S-DYKE, an entrenchment cast up by Offa, a Saxon king, to defend England against the incursions of the Welch. It runs through Hertfordshire, Shropshire, Montgomeryshire, Denbighshire, and Flintshire.

OFFANTO, a river of Italy, in the kingdom of Naples. It rises in the Apennine mountains, in the Farther Principato; and passing by Conza, and Monte Verde, it afterwards separates the Capitanata from the Basilicata and the Terra-di-Barri, and then it falls into the gulf of Venice, near Salpe.

OFFENCE, in law, an act committed against the law, or omitted where the law requires it.

OFFERINGS. The Hebrews had several kinds of offerings, which they presented at the temple. Some were free-will offerings, and others were of obligation. The first-fruits, the tenths, the sin-offerings, were of obligation; the peace-offerings, vows, offerings of wine, oil, bread, salt, and other things, which were made to the temple or to the ministers of the Lord, were offerings of devotion. The Hebrews called all offerings in general *corban*. But the offerings of bread, salt, fruits, and liquors, as wine and oil, which were presented to the temple, they called *mincha*. The sacrifices are not properly offerings, and are not commonly included under that name. See CORBAN and SACRIFICE.

The offerings of grain, meal, bread, cakes, fruits, wine, salt, and oil, were common in the temple. Sometimes these offerings were alone, and sometimes they accompanied the sacrifices. Honey was never offered with the sacrifices; but it might be offered alone in the quality of first fruits. Now these were the rules that were observed in the presenting of those offerings, called in Hebrew *mincha*, or *kerbon mincha*; in the Septuagint, *offerings of sacrifice*; and the same by St Jerom, *oblationem sacrificii*; but by our translators, *meat offerings* (Lev. ii. 1. &c.) There were five sorts of these offerings: 1. Fine flour or meal. 2. Cakes of several sorts, baked in an oven. 3. Cakes baked upon a plate. 4. Another sort of cakes, baked upon a gridiron, or plate with holes in it. 5. The first-fruits of the new corn, which were offered either pure and without mixture, or roasted or parched in the ear, or out of the ear.

The cakes were kneaded with oil-olive, or fried with oil in a pan, or only dipped in oil after they were baked. The bread offered to be presented upon the altar, was to be without leaven; for leaven was never offered upon the altar, nor with the sacrifices. But they might make presents of common bread to the priests and ministers of the temple. See CAKE, &c.

The offerings now mentioned were appointed on account of the poorer sort, who could not go to the charge of sacrificing animals. And even those that offered living victims were not excused from giving meal, wine, and salt, which was to go along with the greater sacrifices. And also those that offered only oblations of bread or of meal, offered also oil, incense, salt,

Oeting
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Offerings.

Offerings,
Office.

salt, and wine, which were in a manner the seasoning of it. The priest in waiting received the offerings from the hand of him that offered them; laid a part of them upon the altar, and reserved the rest for his own subsistence: that was his right as a minister of the Lord. Nothing was burnt quite up but the incense, of which the priest kept back nothing for his own share.

When an Israelite offered a loaf to the priest, or a whole cake, the priest broke the loaf or the cake into two parts, setting that part aside that he reserved to himself, and broke the other into crumbs; poured oil upon it, salt, wine, and incense; and spread the whole upon the fire of the altar. If these offerings were accompanied by an animal for a sacrifice, it was all thrown upon the victim, to be consumed along with it.

If these offerings were the ears of new corn, either of wheat or barley, these ears were parched at the fire or in the flame, and rubbed in the hand, and then offered to the priest in a vessel; over which he put oil, incense, wine, and salt, and then burnt it upon the altar, first having taken as much of it as of right belonged to himself.

The greatest part of these offerings were voluntary, and of pure devotion. But when an animal was offered in sacrifice, they were not at liberty to omit these offerings. Every thing was to be supplied that was to accompany the sacrifice, and which served as a seasoning to the victim. There are some cases in which the law requires only offerings of corn, or bread: for example, when they offered the first-fruits of their harvest, whether they were offered solemnly by the whole nation, or by the devotion of private persons.

As to the quantity of meal, oil, wine, or salt, which was to go along with the sacrifices, we cannot easily see that the law had determined it. Generally the priest threw an handful of meal or crumbs upon the fire of the altar, with wine, oil, and salt in proportion, and all the incense. All the rest belonged to him, the quantity depended upon the liberality of the offerer. We observe in more places than one, that Moses appoints an Assaron, or the tenth part of an ephah of meal, for those that had not wherewithal to offer the appointed sin-offerings (Lev. v. 11. xiv. 21.) In the solemn offerings of the first fruits for the whole nation, they offered an entire sheaf of corn, a lamb of a year old, two tenths or two assarons of fine meal mixed with oil, and a quarter of an hin of wine for the libation (Lev. xxiii. 10. 11. 12, &c.)

In the sacrifice of jealousy (Numb. v. 15.), when a jealous husband accused his wife of infidelity, the husband offered the tenth part of a satum of barley-meal, without oil or incense, because it was a sacrifice of jealousy, to discover whether his wife was guilty or not.

The offerings of the fruits of the earth, of bread, of wine, oil, and salt, are the most ancient of any that have come to our knowledge. Cain offered to the Lord of the fruits of the earth, the first-fruits of his labour (Gen. iv. 3. 4.) Abel offered the firstlings of his flocks, and of their fat. The heathen have nothing more ancient in their religion, than these sorts of offerings made to their gods. They offered clean wheat, flour, and bread.

OFFICE, a particular charge or trust, or a dignity attended with a public function. See HONOUR.—

The word is primarily used in speaking of the offices of judicature and policy; as the office of secretary of state, the office of a sheriff, of a justice of peace, &c.

OFFICE also signifies a place or apartment appointed for officers to attend in, in order to discharge their respective duties and employments; as the secretary's office, ordnance-office, excise-office, signet-office, paper-office, pipe-office, six-clerks office, &c.

OFFICE, in architecture, denotes all the apartments appointed for the necessary occasions of a palace or great house; as kitchen, pantries, confectionaries, &c.

OFFICE, in the canon-law, is used for a benefice that has no jurisdiction annexed to it.

Duty upon OFFICERS and Pensions, a branch of the king's extraordinary perpetual revenue, consisting in a payment of 1s. in the pound (over and above all other duties) out of all salaries, fees, and perquisites, of offices and pensions payable by the crown. This highly-popular taxation was imposed by stat. 31 Geo. II. c. 22. and is under the direction of the commissioners of the land-tax.

OFFICER, a person possessed of a post or office. See the preceding article.

The great officers of the crown, or state, are, The lord high-steward, the lord high-chancellor, the lord high-treasurer, the lord-president of the council, the lord privy-seal, the lord-chamberlain, the lord high-constable, and the earl-marshal; each of which see under its proper article.

Non-commissioned OFFICERS, are serjeant-majors, quarter-master serjeants, serjeants, corporals, drum and fife majors; who are nominated by their respective captains, and appointed by the commanding officers of regiments, and by them reduced without a court-martial.

Orderly non-commissioned OFFICERS, are those who are orderly, or on duty for that week; who, on hearing the drum beat for orders, are to repair to the place appointed to receive them, and to take down in writing, in the orderly book, what is dictated by the adjutant, or serjeant-major: they are then immediately to show these orders to the officers of the company, and afterwards warn the men for duty.

Flag OFFICERS. See *FLAG OFFICERS*, and *ADMIRALS*.

Commission OFFICERS, are such as are appointed by the king's commission. Such are all from the general to the cornet and ensign inclusive. They are thus called in contradistinction to non-commissioned officers. See *Non-Commissioned OFFICERS*.

General OFFICERS, are those whose command is not limited to a single company, troop, or regiment; but extends to a body of forces composed of several regiments: such are the general, lieutenant-general, major-general, and brigadier.

OFFICERS of the Household. See the article *HOUSEHOLD*.

Staff OFFICERS, are such as, in the king's presence, bear a white staff or wand; and at other times, on their going abroad, have it carried before them by a footman bare-headed: such are the lord-steward, lord-chamberlain, lord treasurer, &c.

The white staff is taken for a commission; and, at the king's death, each of these officers breaks his staff over the hearse made for the king's body, and by this means

Office
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Officers.

Officers
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Ogilby.

means lays down his commission, and discharges all his inferior officers.

Subaltern OFFICERS, are all who administer justice in the name of subjects; as those who act under the earl marshal, admiral, &c. In the army, the subaltern officers are the lieutenants, cornets, ensigns, serjeants, and corporals.

OFFICIAL, in the canon law, an ecclesiastical judge, appointed by a bishop, chapter, abbot, &c. with charge of the spiritual jurisdiction of the diocese.

OFFICIAL, is also a deputy appointed by an arch-deacon as his assistant, who sits as judge in the arch-deacon's court.

OFFICINAL, in pharmacy, an appellation given to such medicines, whether simple or compound, as are required to be constantly kept in the apothecaries shops. The *officinal simples* are appointed, among us, by the college of physicians; and the manner of making the compositions directed in their dispensatory. See **PHARMACY**.

OFFING, or **OFFIN**, in the sea-language, that part of the sea a good distance from shore, where there is deep water, and no need of a pilot to conduct the ship: thus, if a ship from shore be seen sailing out to seaward, they say, *she stands for the offing*; and if a ship, having the shore near her, have another a good way without her, or towards the sea, they say, *that ship is in the offing*.

OFF-SETS, in gardening, are the young shoots that spring from the roots of plants; which being carefully separated, and planted in a proper soil, serve to propagate the species.

OFF-SETS, in surveying, are perpendiculars let fall, and measuring from the stationary lines to the hedge, fence, or extremity of an inclosure.

OGEE, or **O. G.** in architecture, a moulding consisting of two members, the one concave and the other convex; or of a round and hollow, like an S. See **ARCHITECTURE**.

OGHAMS, a particular kind of steganography, or writing in cypher practised by the Irish; of which there were three kinds: The first was composed of certain lines and marks, which derived their power from their situation and position, as they stand in relation to one principal line, over or under which they are placed, or through which they are drawn; the principal line is horizontal, and serveth for a rule or guide, whose upper part is called the left, and the under side the right; above, under, and through which line, the characters or marks are drawn, which stand in the place of vowels, consonants, diphthongs, and triphthongs. Some authors have doubted the existence of this species of writing in cypher, called *Ogham* among the Irish; but these doubts are perhaps ill-founded; for several MSS. in this character still exist, from which Mr Astle has given a plate of them.

OGILBY (John), an eminent writer, was born in or near Edinburgh, about the 17th of November 1600. His father having spent his estate, and being prisoner in the King's Bench for debt, could contribute but little to his education; however, he obtained some knowledge in the Latin grammar, and afterwards so much money as to procure his father's discharge from

prison, and to bind himself an apprentice to a dancing-master in London; when, by his dexterity in his profession, and his complaisant behaviour to his master's scholars, he obtained money to buy out the remainder of his time, and to set up for himself. But being afterwards appointed to dance in the duke of Buckingham's great mask, he by a false step strained a vein in the inside of his leg, which occasioned his being ever after somewhat lame. When Thomas earl of Strafford was made lord lieutenant of Ireland, he was entertained as a dancing-master in his family, and made one of the earl's troop of guards; at which time he composed a humorous piece called the *Character of a Trooper*. He was soon after appointed master of the revels in Ireland, and built a theatre at Dublin. About the time of the conclusion of the war in England, he left Ireland, and, being shipwrecked, came to London in a necessitous condition; but soon after walked to Cambridge, where, being assisted by several scholars, he became so complete a master of the Latin tongue, that in 1649 he published a translation of Virgil: He soon after learned Greek; and in 1660 published, in folio, a translation of Homer's Iliad, with Annotations. About two years after he went into Ireland, where he was made master of the revels by patent. He then built another theatre in Dublin, which cost him about 1000 l. He published at London, in folio, a translation of Homer's Odyssey, with Annotations; and afterwards wrote two heroic poems, intitled the *Ephesian Matron*, and the *Roman Slave*. He next composed the Carolics, an epic poem, in 12 books, in honour of king Charles I. but this was entirely lost in the fire of London; when Mr Ogilby's house in White Friars was burnt down, and his whole fortune, except to the value of five pounds, destroyed. He, however, soon procured his house to be rebuilt, set up a printing-office within it, was appointed his majesty's cosmographer and geographic printer, and printed several great works, translated or collected by himself and his assistants, particularly his Atlas. He died in 1676.

OGIVE, in architecture, an arch or branch of a Gothic vault; which, instead of being circular, passes diagonally from one angle to another, and forms a cross with the other arches. The middle, where the ogives cross each other, is called the *key*; being cut in form of a rose, or a *cul de lampe*. The members or mouldings of the ogives are called *nerves*, *branches*, or *reins*; and the arches which separate the ogives, *double arches*.

OGYGES, king of the Thebans, or, according to others, of Ogygia and Actæ, afterwards called *Boeotia* and *Attica*. He is recorded to have been the first founder of Thebes and Eleusin. The famous deluge happened in his time, in which some say he perished with all his subjects, 1796 B. C.

OGYGIA (Homer), the island of Calypso; placed by Pliny in the Sinus Scylaceus, in the Ionian Sea, opposite to the promontory Lacinium; by Mela in the strait of Sicily, calling it *Ææ*; which others place at the promontory Circeium, and call it the island of *Circe*.

OGYGIA, the ancient name of Thebes in Boeotia: so called from Ogyges, an ancient king, under whom happened.

Ogilby
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Ogygia.

Ohio
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Oil.

happened a great deluge, 1020 years before the first Olympiad.

OHIO, a river of North America, called by the French the *Beautiful River*, has its source between the Allegany mountains and the lake Erie; and running south-west through a most delightful country, and also receiving many smaller rivers in its passage, at length falls into the Mississippi, in about 37 degrees of latitude. The French had several forts on and near it; but the whole country through which it flows was ceded by the peace of 1763 to the British.

O HETEROA, one of the South Sea islands lately discovered, is situated in W. Long. 150. 47. S. Lat. 22. 27. It is neither fertile nor populous; nor has it an harbour or anchorage fit for shipping, and the disposition of the people is hostile to such as visit them.

OIL, in natural history, an unctuous inflammable substance, drawn from several natural bodies, as animal and vegetable substances.

Animal oils are their fats, which are originally vegetable oils: all animal substances yield them, together with their volatile salts, in distillation.

Vegetable oils are obtained by expression, infusion, and distillation.

The oils by expression are obtained from the seed, leaves, fruit, and bark of plants; thus, the seed of mustard, and of the sun-flower, almonds, nuts, beech-mast, &c. afford a copious oil by expression; and the leaves of rosemary, mint, rue, wormwood, thyme, sage, &c. the berries of juniper, olives, Indian cloves, nutmeg, mace, &c. the barks of cinnamon, saffras, and clove, yield a considerable proportion of essential oil by distillation.

The method of procuring oils by expression is very simple: thus, if either sweet or bitter almonds, that are fresh, be pounded in a mortar, the oil may be forced out with a press, not heated: and in the same manner should the oil be pressed from linseed and mustard. The avoiding the use of heat, in preparing these oils intended for internal medicinal use, is of great importance, as heat gives them a very prejudicial rancidness.

This method holds of all those vegetable matters that contain a copious oil, in a loose manner, or in certain cavities or receptacles; the sides whereof being broken, or squeezed, makes them let go the oil they contain: and thus the zest or oil of lemon-peel, orange-peel, citron-peel, &c. may be readily obtained by pressure, without the use of fire. But how far this method of obtaining oils may be applied to advantage, seems not hitherto considered. It has been commonly applied to olives, almonds, linseed, rape-seed, beech-mast, ben-nuts, walnuts, bay-berries, mace, nutmeg, &c. but not, that we know of, to juniper-berries, cashew-nuts, Indian cloves, pine-apples, and many other substances that might be enumerated, both of foreign and domestic growth. It has, however, been of late successfully applied to mustard-seed, so as to extract a curious gold-coloured oil, leaving a cake behind, fit for making the common table-mustard.

Certain dry matters, as well as moist ones, may be made to afford oils by expression, by grinding them into a meal, which being suspended to receive the va-

N^o. 245.

pour of boiling water, will thus be moistened so as to afford an oil in the same manner as almonds; and thus an oil may be procured from linseed, hemp-seed, lettuce-seed, white-poppy seed, &c.

As to the treatment of oils obtained by expression, they should be suffered to depurate themselves by standing in a moderately cool place, to separate from their water, and deposit their faeces; from both which they ought to be carefully freed. And if they are not thus rendered sufficiently pure, they may be washed well with fresh water, then thoroughly separated from it again by the separating-glass, whereby they will be rendered bright and clear.

The next class of oils are those made by infusion, or decoction, wherein the virtues of some herb or flower are drawn out in the oil; as the oils of roses, chamomile, hypericum, alder, &c. However, these require to be differently treated: thus, for the scented flowers, particularly roses, insolation does best; because much boiling would exhale their more fragrant parts: but oils impregnated with green herbs, as those of chamomile and alder, require long boiling, before they receive the green colour desired. And, in general, no oils will bear to be boiled any longer than there remains some aqueous humidity, without turning black.

There are many compound oils prepared in the same manner, viz. by boiling and insolation, and then straining off the oil for use.

The same contrivance has likewise its use in making essences for the service of the perfumer; not only where essential oils cannot be well obtained in sufficient quantities, but also where they are too dear. The essential oil of jessamine-flowers, honey-suckles, sweet briar, damask-roses, lilies of the valley, &c. are either extremely dear, or scarcely obtainable by distillation; and, in some of them, the odorous matter is so subtle, as almost to be lost in the operation. But if these flowers be barely infused in fine oil of nuts, or oil of ben, drawn without heat, and kept in a cool place, their subtle odorous matter will thus pass into the oil, and richly impregnate it with their flavour. And these essences may be rendered still more perfect by straining off the oil at first put on, and letting it stand again, without heat, upon fresh flowers; repeating the operation twice or thrice.

Oils or fats may likewise be obtained, by boiling and expression, from certain animal-substances; for the membranes which contain the fat, being chopped small, and set in a pan over the fire, become fit for the canvas bag, and, by pressure, afford a large quantity of fat; as we see in the art of chandlery, which thus extracting the oily matter, leaves a cake behind, commonly called *graves*.

As to the essential oils of vegetables, they are obtained by distillation with an alembic and a large refrigeratory. Water must be added to the materials, in sufficient quantity, to prevent their burning; and they should be macerated or digested in that water, a little time before distillation. The oil comes over with the water; and either swims on the top, or sinks to the bottom, according as it is specifically heavier or lighter than water.

This process is applicable to the distilling of the essential oils from flowers, leaves, barks, roots, woods, gums,

Oil.

gums, and balsams, with a slight alteration of circumstances, as by longer digestion, brisker distillation, &c. according to the tenacity and hardness of the subject, the ponderosity of the oil, &c.

Essential oils may be divided into two classes, according to their different specific gravities; some floating upon water, and others readily sinking to the bottom. Thus, the essential oils of cloves, cinnamon, and saffra, readily sink, whereas those of lavender, marjoram, mint, &c. swim, in water: the lightest of these essential oils is, perhaps, that of citron-peel, which even floats in spirit of wine; and the heaviest seems to be oil of saffra.

For obtaining the full quantity of the more ponderous oils from cinnamon, cloves, saffra, &c. it is proper to reduce the subjects to powder; to digest this powder for some days in a warm place, with thrice its quantity of soft river-water, made very saline by the addition of sea-salt, or sharp with oil of vitriol; to use the strained decoction, or liquor left behind in the still, instead of common water, for fresh digestion; to use for the same purpose the water of the second running, after being cleared of its oil; not to distil too large a quantity of these subjects at once; to leave a considerable part of the still, or about one fourth, empty; to use a brisk fire, or a strong boiling heat, at the first, but to slacken it afterwards; to have a low still-head, with a proper internal ledge and current leading to the nose of the worm; and, finally, to cohobate the water, or pour back the liquor of the second running upon the matter in the still, repeating this once or twice.

The directions here laid down for obtaining the ponderous oils to advantage, are easily transferred to the obtaining of the lighter; so that we need not dwell particularly upon them.

Many of the essential oils being dear, it is a very common practice to adulterate or debase them several ways, so as to render them cheaper both to the seller and the buyer. These several ways seem reducible to three general kinds, each of which has its proper method of detection, viz. 1. With expressed oils. 2. With alcohol. And, 3. With cheaper essential oils.

If an essential oil be adulterated with an expressed oil, it is easy to discover the fraud; by adding a little spirit of wine to a few drops of the suspected essential oil, and shaking them together; for the spirit will dissolve all the oil that is essential, or procured by distillation, and leave all the expressed oil that was mixed with it, untouched.

If an essential oil be adulterated with alcohol, or rectified spirit of wine, it may be done in any proportion, up to that of an equal quantity, without being easily discoverable either by the smell or taste: the way to discover this fraud, is to put a few drops of the oil into a glass of fair water; and if the oil be adulterated with spirit, the water will immediately turn milky, and, by continuing to shake the glass, the whole quantity of spirit will be absorbed by the water, and leave the oil pure at top.

Finally, if an essential oil be adulterated by a cheaper essential oil, this is commonly done very artfully: the method is to put fir-wood, turpentine, or oil of

turpentine, into the still, along with the herbs to be distilled for their oil, such as rosemary, lavender, origanum, &c. and by this means the oil of turpentine distilled from these ingredients comes over in great quantity, and intimately blended with the oil of the genuine ingredient. The oils thus adulterated always discover themselves in time, by their own flavour being overpowered by the turpentine-smell: but the ready way to detect the fraud, is to drench a piece of rag, or paper, in the oil, and hold it before the fire; for thus the grateful flavour of the plant will fly off, and leave the naked turpentine-scent behind.

The virtues of oils, being the same with those of the substances from whence they are obtained, may be learned under their several articles, to which we refer.

We have this account of different oils in the island of Madagascar in the Universal History.

Oils are of different sorts; the most common are those of menach-tanhetanhe, menach signifying oil, menachil, menach-chouivau, menach-mafoutra, menach-vourave, menach-apocapouc, menach-vintang, and menach arame. Menach-tanhetanhe is drawn from a particular plant, called, in the language of the country, *tanbetanhe*, and known in Europe by the name of *palma Christi*, or *Ricinus*. Menachil is an oil from the seed of sesame, which they call *voancaze*; a great quantity whereof is made in the valley of Amboule. Menach-chouivau is drawn from a fruit of the size of an almond, extremely good in liquors or meats. Menach-mafoutra is drawn from nuts, the fruit of the tree which produces dragon's blood. Menach-vourave is drawn from a fruit named *fontsi*. Menach-apocapouc is squeezed from the fruit apocapouc, extremely poisonous. Menach-vintang is an oil from large acorns, or mast. Menach-aramé is drawn from nuts, the fruit of the tree from which the gum *tacamahaca* is produced.

Rock Oil. See PETROLEUM.

Essential Oil of Roses. See ROSES.

Method of Purifying Rancid Oils. See CHEMISTRY, n° 1431.

OINTMENT, in pharmacy. See UNGUENT.

OKEHAM, the capital of Rutlandshire, in England, seated in a rich and pleasant valley, called the *vale of Catmus*. It is pretty well built, has a good church, a free-school, and an hospital. W. Long. o. 45. N. Lat. 52. 40.

OKINGHAM, OCKINGHAM, or *Woxingham*, a large town of Berkshire, in England, noted for the manufacture of silk stockings. W. Long. o. 50. N. Lat. 51. 26.

OLAUS MAGNUS. See MAGNUS.

OKRA. See HIBISCUS.

OLAX, in botany: A genus of the monogynia order, belonging to the triandria class of plants; and in the natural method ranking with those of which the order is doubtful. The calyx is entire; the corolla funnel-shaped and trifid; the nectarium tetraphyllous.

OLD AGE. See LONGEVITY. Many methods have been proposed for lengthening life, and rendering old age comfortable. Cornara's Treatise on this subject is known to every body, and needs not be quoted. To some of our readers the following set of

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resolutions

Oil
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Old.

Old.

resolutions will perhaps be new, and may certainly be useful.

The old men should resolve, except the reasons for a change be invincible, to live and to die in the public profession of the religion in which they were born and bred. To avoid all profane talk and intricate debates on sacred topics. To endeavour to get the better of the intrusions of indolence of mind and body, those certain harbingers of enfeebling age. Rather to wear out, than to rust out. To rise early, and as often as possible to go to bed before midnight. Not to nod in company, nor to indulge repose too frequently on the couch in the day. To waste as little of life in sleep as may be, for we shall have enough in the grave. Not to give up walking; nor to ride on horseback to fatigue. Experience, and a late medical opinion, determine to ride five miles every day. Nothing contributes more to the preservation of appetite, and the prolongation of life. Cheyne's direction to the valetudinary, "to make exercise a part of their religion," to be religiously observed. To continue the practice of reading, pursued for more than fifty years, in books on all subjects; for variety is the salt of the mind as well as of life. Other people's thoughts, like the best conversation of one's companions, are generally better and more agreeable than one's own. Frequently to think over the virtues of one's acquaintance, old and new. To admit every cheerful ray of sunshine on the imagination. To avoid retrospection on a past friendship, which had much of love in it; for memory often comes when she is not invited. To try to think more of the living and less of the dead; for the dead belong to a world of their own. To live within one's income, be it large or little. Not to let passion of any sort run away with the understanding. Not to encourage romantic hopes nor fears. Not to drive away hope, the sovereign balm of life, though he is the greatest of all flatterers. Not to be under the dominion of superstition or enthusiasm. Not wilfully to undertake any thing for which the nerves of the mind or the body are not strong enough. Not to run the race of competition, or to be in another's way. To avoid being jostled too much in the street, being overcome by the noise of the carriages, and not to be carried even by curiosity itself into a large crowd. To strive to embody that dignified sentiment, "to write injuries in dust, but kindnesses in marble." Not to give the reins to constitutional impatience, for it is apt to hurry on the first expressions into the indecency of swearing. To recollect, that he who can keep his own temper may be master of another's. If one cannot be a stoic, in bearing and forbearing, on every trying occasion, yet it may not be impossible to pull the check-string against the moroseness of spleen or the impetuosity of peevishness. Anger is a short madness. Not to fall in love, now on the precipice of threescore, nor expect to be fallen in love with. A connection between summer and winter is an improper one. Love, like fire, is a good servant, but a bad master. Love is death, when the animal spirits are gone. To contrive to have as few vacant hours upon one's hands as possible, that idleness, the mother of crimes and vices, may not pay its visit. To be always doing of something, and to have something to do. To fill up one's time, and to have a good deal

to fill up; for time is the materials that life is made of. If one is not able by situation, or through the necessity of raising the supplies within the year, or by habit (for virtue itself is but habit), to do much ostentatious good, yet do as little harm as possible. To make the best and the most of every thing. Not to indulge too much in the luxury of the table, nor yet to underlive the constitution. The gout, rheumatism, and dropsy, in the language of the Spectator, seem to be hovering over the dishes. Wine, the great purveyor of pleasure, and the second in rank among the senses, offers his service, when love takes his leave. It is natural to catch hold of every help, when the spirits begin to droop. Love and wine are good cordials, but are not proper for the beverage of common use. Resolve not to go to bed on a full meal. A light supper and a good conscience are the best receipts for a good night's rest, and the parents of undisturbing dreams. Not to be enervated by the flatulency of tea. Let the second or third morning's thought be to consider of the employment for the day; and one of the last at night to inquire what has been done in the course of it. Not to let one's tongue run at the expence of truth. Not to be too communicative nor unreserved. A close tongue, with an open countenance, are the safest passports through the journey of the world. To correct the error of too much talking, and restrain the narrativeness of the approaching climacteric. To take the good-natured side in conversation. However, not to praise every body, for that is to praise no body. Not to be inquisitive, and eager to know secrets, nor be thought to have a head full of other people's affairs. Not to make an enemy, nor to lose a friend. To aim at the esteem of the public, and to leave a good name behind. Not to be singular in dress, in behaviour, in notions, or expressions of one's thoughts. Never to give bad advice, and to strive not to set a bad example. Seldom to give advice till asked, for it appears like giving something that is superfluous to one's self. Not to like or dislike too much at first sight. Not to wonder, for all wonder is ignorance that possession falls short of expectation. The longing of twenty years may be disappointed in the unanswered gratification of a single hour. Whilst we are wishing, we see the best side; after we have taken possession, the worst. Resolved to attend to the arguments on both sides, and to hear every body against every body. The mind ought not to be made up, but upon the best evidence. To be affectionate to relations, which is a kind of self-love, in preference to all other acquaintance. But not to omit paying the commanding respect to merit, which is superior to all the accidental chains of kindred. Not to debilitate the mind by new and future compositions. Like the spider, it may spin itself to death. The mind, like the field, must have its fallow season. The leisure of the pen has created honourable acquaintance, and pleased all it has wished to please. To resolve not to be too free of promises, for performances are sometimes very difficult things. Not to be too much alone, nor to read, nor meditate, or talk too much on points that may awaken tender sensations, and be too pathetic for the soul. To enjoy the present, not to be made too unhappy by reflection on the past, nor to be oppressed by invincible gloom on the

Old.

Old
Oldenburg.

the future. To give and receive comfort, those necessary alms to a distressed mind. To be constantly thankful to Providence for the plenty hitherto possessed, which has preserved one from the dependence on party, persons, and opinions, and kept one out of debt. The appearance of a happy situation, and opportunities of tasting many worldly felicities (for content has seldom perverted itself into discontent), has induced many to conclude, that one must be pleased with one's lot in life; and it occasions many to look with the eye of innocent envy. To resolve more than ever to shun every public station and responsibility of conduct. To be satisfied with being master of one's self, one's habits, now a second nature, and one's time. Determined not to solicit, unless trampled upon by fortune, to live and die in the harness of trade, or a profession. To take care that pity (humanity is not here meant) does not find out one in the endurance of any calamity. When pity is within call, contempt is not far off. Not to wish to have a greater hold of life, nor to quit that hold. The possible tenure of existence is of too short possession for the long night that is to succeed: therefore not a moment to be lost. Not to lose sight, even for a single day, of these good and proverbial doctors—diet—merryman—and quiet. Resolved to remember and to recommend, towards tranquillity and longevity, the three oral maxims of Sir Hans Sloane—"Never to quarrel with one's self—one's wife—or one's prince." Lastly, not to put one's self too much in the power of the elements, those great enemies to the human frame; namely, the sun—the wind—the rain—and the night air.

OLD-Man of the Mountain. See ASSASSINS.

OLDCASTLE (Sir John), called the *Good Lord Cobham*, was born in the reign of Edward III. and was the first author as well as the first martyr among the English nobility: he obtained his peerage by marrying the heiress of that Lord Cobham who with so much virtue and patriotism opposed the tyranny of Richard II. By his means the famous statute against provisors was revived, and guarded against by severer penalties; he was one of the leaders of the reforming party; was at great expence in procuring and dispersing copies of Wickliffe's writings among the people, as well as by maintaining a number of his disciples as itinerant preachers. In the reign of Henry V. he was accused of heresy; the growth of which was attributed to his influence. Being a domestic in the king's court, the king delayed his prosecution that he might reason with him himself; but not being able to reclaim him to the church of Rome, he in great displeasure resigned him to its censure. He was apprehended and condemned for heresy; but escaping from the tower, lay concealed for four years in Wales, until the rumour of a pretended conspiracy was raised against him, and a price set upon his head: he was at last seized, and executed in St Giles's Fields; being hung alive in chains upon a gallows, and burned by a fire placed underneath. He wrote "Twelve Conclusions, addressed to the Parliament of England."

OLDENBURG, a title of the royal house of Denmark. The origin of this illustrious family, we are told, is this.

On the death of Christopher king of Denmark, &c. in 1448, without issue, there was a great contest about

the succession; and a variety of factions were raised, Oldenburg, particularly in Sweden and Norway, for the promotion of different persons, and various animosities and numerous discords were excited by the several parties, in order each to obtain their own ends.

As soon as these intrigues were known in Denmark, the senate resolved to proceed to the election of a king; for it did not appear expedient to commit the government of affairs to the queen-dowager, at a time when they had every thing to fear from the two neighbouring crowns. At this time a lord of great weight, property, and ambition, sought the queen in marriage, the more easily to pave his way to the throne. This is a fact mentioned by Pontanus and Meursius, though neither takes notice of his name. But as for a great number of years there was no precedent for electing a king out of the body of nobility, though agreeable to law, the queen entered into the views of the senate, and declared she would give her hand to no prince who should not be judged deserving of the crown by the supreme council of the nation.

The advantages which would have accrued from annexing the duchy of Sleswick and Holstein to the crown, made the senate first cast their eyes on Adolphus. This matter required no long deliberation; all saw the conveniencies resulting from such an union, and gave their assent. Immediately an embassy was dispatched with the offer to Adolphus; but that prince consulting the good of his subjects, whose interest would have been absorbed in the superior weight of Denmark, declined it, with a moderation and disinterestedness altogether uncommon among princes. However, that he might not be wanting in respect to the senate, he proposed to them his nephew Christian, second son to Theodoric, count of Oldenburg, a prince bred up at the court of Adolphus from his infancy. The proposition was so agreeable to the senate, that, without loss of time, the ambassadors were sent to Theodoric, to demand either of his sons he should pitch upon for their king. Theodoric's answer to the ambassadors was remarkable: "I have three sons, says he, of very opposite qualities. One is passionately fond of pleasure and women; another breathes nothing but war, without regarding the justice of the cause; but the third is moderate in his disposition, prefers peace to the din of arms, yet stands unrivalled in valour, generosity, and magnanimity." He said he painted these characters for the senate's information, desiring they would choose which of the young princes they believed would render the kingdom happiest. It was a matter which would admit of no hesitation: with one voice the senate declared for that prince whose panegyric the father had so warmly drawn; and under these happy auspices commenced the origin of the grandeur of the house of Oldenburg, at this day seated on the throne of Denmark.

OLDENBURG (Henry), a learned German gentleman in the 17th century, was descended from the noble family of his name, who were earls of the county of Oldenburg, in the north part of Westphalia, for many generations. He was born in the duchy of Bremen in the Lower Saxony; and during the long English parliament in King Charles I.'s time, was appointed consul for his countrymen, at London, after the usurpation of Cromwell: but being discharged of

Oldenburg
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Oldham.

that employ, he was made tutor to the lord Henry O'Bryan, an Irish nobleman, whom he attended to the university of Oxford, where he was admitted to study in the Bodleian library in the beginning of the year 1656. He was afterwards tutor to William lord Cavendish, and was acquainted with Milton the poet. During his residence at Oxford, he became also acquainted with the members of that body there which gave birth to the royal society; and upon the foundation of this latter, he was elected fellow; and when the society found it necessary to have two secretaries, he was chosen assistant-secretary to Dr Wilkins. He applied himself with extraordinary diligence to the business of his office, and began the publication of the Philosophical Transactions with N^o 1. in 1664. In order to discharge this task with greater credit to himself and the society, he held a correspondence with more than seventy learned persons, and others, upon a vast variety of subjects, in different parts of the world. This fatigue would have been insupportable, had not he, as he told Dr Lister, managed it so as to make one letter answer another; and that to be always fresh, he never read a letter before he had pen, ink, and paper, ready to answer it forthwith; so that the multitude of his letters cloyed him not, nor ever lay upon his hands. Among others, he was a constant correspondent of Mr Robert Boyle, with whom he had a very intimate friendship; and he translated several of that ingenious gentleman's works into Latin.

Mr Oldenburg continued to publish the Transactions, as before, to n^o xxxvi. June 25. 1677. After which the publication was discontinued till the January following, when it was again resumed by his successor in the secretary's office, Mr Nehemiah Grew, who carried it on till the end of February 1678. Our author dying at his house at Charleton, near Greenwich in Kent, in the month of August that year, was interred there.

OLDENLANDIA, in botany: A genus of the tetrandria monogynia class. Its characters are these: The empalement of the flower is permanent, sitting upon the germen; the flower has four oval petals, which spread open, and four stamina, terminated by small summits; it hath a roundish germen, situated under the flower, crowned by an indented stigma; the germen afterwards turns to a globular capsule, with two cells filled with small seeds. We have but one species of this plant in the English gardens; but Linnæus enumerates six.

OLDHAM (John), an eminent English poet in the 17th century, son of a nonconformist minister, was educated under his father, and then sent to Edmund-hall in Oxford. He became usher to the free-school at Croydon in Surry; where he received a visit from the earls of Rochester and Dorset, Sir Charles Sedley, and other persons of distinction, merely upon the reputation of some verses of his which they had seen in manuscript. He was tutor to several gentlemen's sons successively; and having saved a small sum of money, came to London, and became a perfect votary to the bottle, being an agreeable companion. He was quickly found out here by the noblemen who had visited him at Croydon, who brought him acquainted with Mr Dryden. He lived mostly with the earl of Kingston at Holme-Pierpoint in Not-

tinghamshire, where he died of the smallpox in 1683, in the 30th year of his age. His acquaintance with learned authors appears by his satires against the Jesuits, in which there is as much learning as wit discovered. Mr Dryden esteemed him highly. His works are printed in 2 vols 12mo. They chiefly consist of satires, odes, translations, paraphrases of Horace and other authors, elegiac verses, imitations, parodies, familiar epistles, &c.

OLD-HEAD, situated in the county of Cork, and province of Munster, four miles south of Kinsale, in the barony of Courcies, Ireland: it is a promontory, running far into the sea, on which is a light-house for the convenience of shipping.—A mile from its extremity is an ancient castle of the lords of Kinsale, built from one side of the Isthmus to the other, which defended all the lands towards the head: this place was formerly called *Duncearma*, and was the old seat of the Irish kings. The Isthmus, by the working of the sea, was quite penetrated through, so as to form a stupendous arch, under which boats might pass from one bay to the other. Among the rocks of this coast there are aviaries of good hawks; also the sea-eagle or osprey build their nests and breed in them.

OLDMIXON (John), was descended from an ancient family in Somersetshire: he was a violent party-writer and malevolent critic, who would scarcely have been remembered, if Pope, in resentment of his abuse, had not condemned him to immortality in his *Dunciad*. His party-writings procured him a place in the revenue at Liverpool, where he died at an advanced age in the year 1745. Besides his fugitive temporary pieces, he wrote a History of the Stuarts in folio; a Critical History of England, 2 vols 8vo; a volume of Poems, some dramatic pieces, &c.; none of them worthy of notice, his principal talent being that of falsifying history.

OLD-WIFE, or *Wrasse*. See **LABRUS**.

OLD-WIFE Fish, See **BALISTES**.

OLD-WOMAN'S ISLAND, a narrow slip of land, about two miles long, separated from Bombay in the East Indies by an arm of the sea, which, however, is passable at low water. It terminates at one extremity in a small eminence, on which a look-out house is kept for vessels. Near the middle are three tombs kept constantly white, as land-marks into the harbour. From the end of the island a dangerous ledge of rocks shoots forth, which are not very easily cleared. It produces only pasture for a few cattle.

OLEA, in botany, the *olive-tree*: A genus of the monogynia order, belonging to the diandria class of plants; and in the natural method ranking under the 44th order, *Sapieria*. The corolla is quadrifid, with the segments nearly ovate. The fruit is a monospermous plum.

There are three species of the olea. 1. The *Europea*, or common olive-tree, rises with upright solid stems, branching numerously on every side, 20 or 30 feet high; spear-shaped, stiff, opposite leaves, two or three inches long, and half an inch or more broad; and at the axillas small clusters of white flowers, succeeded by oval fruit.

This species is the principal sort cultivated for its fruit; the varieties of which are numerous, varying in size, colour, and quality.

Old-Head
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Olea.

Olea.

It is a native of the southern warm parts of Europe, and is cultivated in great quantities in the south of France, Italy, and Portugal, for the fruit to make the olive-oil, which is in so great repute, and is transported to all parts, to the great advantage of those countries where the trees grow in the open ground: the green fruit is also in much esteem for pickling, of which we may see plenty in the shops.

2. The *capensis*, or cape box-leaved olive, rises with shrubby stems, branching numerously from the bottom, six or seven feet high; small, oval, thick, stiff, shining leaves; and at the axillas small clusters of whitish flowers; succeeded by small fruit of inferior value.

3. *Olea odoratissima* (Indian name, *quesa*; Japanese name, *Skio Ran*, it: *Sju Ran*) is thus described by Thunberg, *bulbis fibrosis, foliis ensiformibus, sessilibus, floribus pendulis*. (See Plate CCCXLIX.) The flower of the *olea odoratissima* is by some said to give the fine flavour to the green tea; but Thunberg attributes the said flavour to the *Cemellie seferque*.

Olive-trees are easily propagated by shoots; which, when care has been taken to ingraft them properly, bear fruit in the space of eight or ten years. Those kinds of olive-trees which produce the purest oil, and bear the greatest quantity of fruit, are ingrafted on the stocks of inferior kinds.

Different names are assigned by the French to the different varieties of the olive-tree; and of these they reckon 19, whilst in Florence are cultivated no fewer than 32.

Olive shoots are ingrafted when in flower. If the operation has been delayed, and the tree bears fruit, it is thought sufficient to take off a ring of bark, two fingers breadth in extent, above the highest graft. In that case the branches do not decay the first year; they afford nourishment to the fruit, and are not lopped off till the following spring. Olive-trees are commonly planted in the form of a quincunx, and in rows at a considerable distance from one another. Between the rows it is usual to plant vines, or to sow some kind of grain. It is observed, that olives, like many other fruit-trees, bear well only once in two years. The whole art of dressing these trees consists in removing the superfluous wood; for it is remarked, that trees loaded with too much wood produce neither so much fruit nor of so good a quality.

Their propagation in England is commonly by layers.

The laying is performed on the young branches in spring. Give plenty of water all summer, and they will sometimes be rooted and fit for potting off in autumn; but sometimes they require two summers to be rooted effectually: when, however, they are properly rooted, take them off early in autumn, and pot them separately; give water, and place them in the shade till they have taken fresh root; and in October remove them into the green-house, &c.

Those you intend to plant in the open ground, as before suggested, should be kept in pots, in order to have occasional shelter of a garden-frame two or three years, till they have acquired some size, and are hardened to the full air; then transplant them into a warm border against a wall: mulch their roots in winter, and mat their tops in frosty weather.

Olea.

Olives have an acrid, bitter, extremely disagreeable taste: pickled (as we receive them from abroad) they prove less disagreeable. The Lucca olives, which are smaller than the others, have the weakest taste; the Spanish, or larger, the strongest; the Provence, which are of a middling size, are generally the most esteemed.

When olives are intended for preservation, they are gathered before they are ripe. The art of preparing them consists in removing their bitterness, in preserving them green, and in impregnating them with a brine of aromatised sea-salt, which gives them an agreeable taste. For this purpose different methods are employed. Formerly they used a mixture of a pound of quicklime, with six pounds of newly sifted wood-ashes; but of late, instead of the ashes, they employ nothing but a lye. This, it is alleged, softens the olives, makes them more agreeable to the taste, and less hurtful to the constitution. In some parts of Provence, after the olives have lain some time in the brine, they remove them, take out the kernel, and put a caper in its place. These olives they preserve in excellent oil; and when thus prepared, they strongly stimulate the appetite in winter. Olives perfectly ripe are soft and of a dark-red colour. They are then eaten without any preparation, excepting only a seasoning of pepper, salt, and oil; for they are extremely tart, bitter, and corrosive.

The oil is undoubtedly that part of the produce of olive-trees which is of greatest value. The quality of it depends on the nature of the soil where the trees grow, on the kind of olive from which it is expressed, on the care which is taken in the gathering and pressing of the fruit, and likewise on the separation of the part to be extracted. Unripe olives give an intolerable bitterness to the oil; when they are over ripe, the oil has an unguinous taste: it is therefore of importance to choose the true point of maturity. When the situation is favourable, those species of olives are cultivated which yield fine oils; otherwise, they cultivate such species of trees as bear a great quantity of fruit, and they extract oil from it, for the use of soap-eries, and for lamps.

They gather the olives about the months of November or December. It is best to put them as soon as possible into baskets, or into bags made of wool or hair, and to press them immediately, in order to extract a fine oil. Those who make oil only for soap-eries, let them remain in heaps for some time in their storehouses; when afterwards pressed, they yield a much greater quantity of oil. Those even who extract oil to be used in food, sometimes allow them to ferment in heaps, that they may have more oil; but this is extremely hurtful to the quality of the oil, and is the reason why fine oil is so very rare. M. Duhamel recommends not to mix sound olives with those in which a fermentation has already begun, and still less with such as are putrified: in both cases, the oil which is extracted is of a bad quality, and unfit for preservation. In order to have the oil in its purity, we must allow it to deposit its sediment, and then pour it off into another vessel. The oil extracted from the pulp only of olives is the most perfect which can be obtained, and will keep for several years; but that which

Olea.

is extracted from the kernel only, or from the nut, or from the whole olive ground in the common way in public mills, has always more or fewer defects, loses its limpidity in a certain time, and is very apt to become rancid. Care must be taken likewise to keep the oil in proper vessels well shut. After all, in the course of time, olive-oil loses its qualities, becomes disagreeable to the taste and smell, diminishes in fluidity, and at length thickens considerably.

The refuse of the first pressing, when squeezed a second time, yields an oil, but thicker and less pure than the former. What remains after the second pressing, when mixed with a little water and placed in a pan over the fire, produces by pressure a third oil, but of a very inferior quality. What remains after all the oil is expressed, is termed *grignon*, and is of no farther use but as fuel.

The sediment, or *faces*, of new oil, we name after the ancients, *amura*: it is an excellent remedy in rheumatic affections. In Paris the wax used for shoes is commonly made of the dregs of defecated oil and smoke-black.

Oil of olives is an ingredient in the composition of a great many balsams, ointments, plasters, mollifying and relaxing liniments. It is of an emollient and solvent nature; mitigates gripes of the colic, and the pains accompanying dysentery; and is one of the best remedies when one has chanced to swallow corrosive poisons; but it by no means prevents the fatal accidents which ensue from the bite of a snake, as has been pretended. It is an effectual cure, as M. Bourgeois tells us, for the sting of wasps, bees, and other insects. A bandage soaked in the oil is immediately applied to the sting, and a cure is obtained without any inflammation or swelling.

Olive oil is of no use in painting, because it never dries completely. The best soap is made of it, mixed with Alicant salt-wort and quicklime.

Great drought, as well as much rain, is extremely injurious to the crop of olives. This fruit is much exposed to the attacks of a worm peculiar to itself, and which injures it so much, that after the olives are gathered the produce of the oil extracted from them is diminished one half.

The wood of the olive-tree is beautifully veined, and has a pretty agreeable smell: it is in great esteem with cabinet-makers, on account of the fine polish which it assumes. It is of a resinous nature, and consequently excellent for burning.

As the laurel branch is the symbol of glory, so the olive-branch covered with leaves has from the most ancient times been the emblem of concord, the symbol of friendship and peace.

The leaves of olive-trees have an astringent quality. Many people use them in making gargles for inflammations of the throat.

These plants in this country must be kept principally in pots for moving to the shelter of a green-house in winter; for they are too tender to prosper well in the open ground in this climate: though sometimes they are planted against a warm south wall, and sheltered occasionally from frost in winter, by mulching the roots, and matting their tops; whereby they may be preserved, and will sometimes produce fruit for pickling: a very severe winter, however, often kills or greatly

injures their young branches; therefore let the principal part be potted in rich earth, and placed among the green-house shrubs, and managed as others of that kind.

These trees are often sent over from Italy to the Italian warehouses in London, along with orange-trees, &c. where pretty large plants may be purchased reasonably, which should be managed as directed for orange-trees that are imported from the same country. See CITRUS.

OLEAGINOUS, something that partakes of the nature of oil, or out of which oil may be expressed.

OLEANDER, or ROSE BAY, *nerium*: A genus of the pentandria monogynia class. Its characters are these: The empalement of the flower is permanent, and cut into five acute segments; the flower has one funnel-shaped petal, cut into five broad obtuse segments, which are oblique; it hath a nectarium, terminating the tube, which is torn into hairy segments; it hath five short awl-shaped stamina within the tube; it hath an oblong germen, which is bifid, with scarce any style, crowned by single stigmas; the germen afterwards turns to two long, taper, acute-pointed pods, filled with oblong seeds lying over each other like the scales of a fish, and crowned with down. There are four species.

These plants are generally propagated by layers in this country; for although they will take root from cuttings, yet that being an uncertain method, the other is generally preferred; and as the plants are very apt to produce suckers or shoots from their roots, those are best adapted for laying; for the old branches will not put out roots: when these are laid down, they should be slit at a joint, in the same manner as is practised in laying of carnations. There are few plants which are equal to them either to the sight or smell, for their scent is very like that of the flowers of the white thorn; and the bunches of flowers will be very large if the plants are strong.

It is called *nerium* from *νηρος*, "humid," because it grows in humid places. The plant itself has a force which is insuperable; for its juice excites so great and violent an inflammation, as immediately to put a stop to deglutition; and if it be received into the stomach, that part is rendered incapable of retaining any thing; the pernicious drug exerting its force, and purging both upwards and downwards.

Nerium in qualities resembles the apocynum. See APOCYNUM. But when handled and examined upon an empty stomach, in a close chamber, it causes a numbness coming by degrees, with a pain in the head; which shows that something poisonous belongs even to the smell, though there is no danger if it be received in the open air, as may be found upon trial. Antidotes against its poison are vinegar and all acids.

OLEARIUS (Adam), minister to the duke of Holstein, and secretary to the embassy sent in 1633 to the great duke of Muscovy and to the king of Persia. He spent six years in this employment; and, on his return, published a relation of his journeys, with maps and figures, at Sleswic, 1656, in folio. He wrote an *Abridgement of the Chronicles of Holstein from 1448 to 1663*; and was appointed librarian to the duke of Holstein, in which capacity he probably died. He has the character of an able mathematician, an adept of

Oleaginous
||
Olearius

Olearius of music, and a good orientalist, especially in the Persian language.

Oleum.

OLEARIUS (Godfrey), son of Godfrey Olearius, D. D. superintendant of Halle in Saxony, was born there in 1639. He became professor of Greek at Leipzig; and showed his abilities in that language by 52 exercitations on the dominical epistles, and upon those parts of the epistles in the New Testament which are read in the public exercises, and which among the Lutherans are the subject of part of their sermons. He discharged the most important posts in the university, and among other dignities was ten times rector of it. His learning and industry were displayed in 106 theological disputations, 61 in philosophy, some programmas upon difficult points, several speeches and theological counsels; which make two thick volumes: beside his Moral Theology, his introduction to Theology, which treats of cases of conscience, and his *Hermeneutica Sacra*. He lived to a good old age, dying in 1713. His eldest son of his own name was a man of genius and learning, a professor in the same university, who published several works, but died young of a consumption before his father.

OLECRANUM, or **OLECRANON**, in anatomy, the protuberance of the ulna, which prevents the joint of the elbow from being bent back beyond a certain length. See **ANATOMY**, n° 51.

OLENUS, a Greek poet, older than Orpheus, came from Xanthe, a city of Lycia. He composed several hymns, which were sung in the island of Delos upon festival days. Olenus is said to have been one of the founders of the oracle at Delphi; to have been the first who filled at that place the office of priest of Apollo; and to have given responses in verse: but the truth of these assertions is very doubtful.

OLERON, an island of France, on the coast of Aunis and Saintonge, about five miles from the continent. It is 12 miles in length, and five in breadth; and is very fertile, containing about 12,000 inhabitants, who are excellent seamen. It is defended by a castle, which is well fortified; and there is a lighthouse placed there for the direction of ships. It is 14 miles south-east of Rochelle. W. Long. 1. 26. N. Lat. 46. 10.

Sea-Laws of OLERON, certain laws relative to maritime affairs, made in the time of Richard I. when he was at the island of Oleron. These laws, being accounted the most excellent sea-laws in the world, are recorded in the black book of the admiralty. See *Selden's Mare Clausum*.

OLEUM PALMÆ CHRISTI, commonly called *castor oil*, is extracted from the kernel of the fruit produced by the *Ricinus Americanus*. (See **RICINUS**). This oil has been much used as a purgative in medicine. It acts gently on the bowels, with little or no irritation. By many physicians it has been deemed a sovereign remedy in bilious, calculous, and nephritic complaints; but its taste is extremely nauseous, and, when frequently used, it is apt to relax the tone of the bowels. It is recommended to be given in clysters; and Dr Canvane of Bath affirms, that when children cannot be made to swallow any medicine, if the navel and hypochondria be rubbed with this oil, it will produce one or two physical stools. He adds, that

given in small draughts, or by clyster, or by embrocation, it is an excellent and wonderful vermifuge.

OLFACTORY NERVES. See **ANATOMY**, n° 136 and 140.

OLGA, queen of Igor the second monarch of Russia, who flourished about the year 880, having succeeded his father Ruric, who died in 878. Olga was born in Plescow, and was of the best family in that city. She bore him one son, called *Swetoflaw*. Igor being murdered by the Drewenses, or Drewliani, Olga revenged his death. She went afterwards, for what reason we know not, to Constantinople, where she was baptized, and received the name of *Helena*.

The emperor John Zimisces was her god-father, and fell in love with her as we are told: but she, alleging their spiritual alliance, refused to marry him. Her example made some impression upon her subjects, a good number of whom became converts to Christianity; but none upon her son, who reigned for a long time after her death, which happened at Pereflaw, in the 80th year of her age, 14 years after her baptism. The Russians to this day rank her among their saints, and commemorate her festival on the 11th of July.

OLIBANUM, in pharmacy, a gummy resin, the product of the *juniperus lycia* (Lin.), brought from Turkey and the East Indies, usually in drops or tears like those of mastich, but larger; of a pale yellowish, and sometimes reddish, colour; a moderately warm pungent taste, and a strong, not very agreeable smell. This drug has received many different appellations, according to its different appearances: the single tears are called simply *olibanum*, or *thus*; when two are joined together, they have been called *thus masculum*, and when very large, *thus femininum*: sometimes four or five, about the bigness of filberts, are found adhering to a piece of the bark of the tree which they exuded from; these have been named *thus corticosum*: the finer powder which rubs off from the tears in the carriage, *mica thuris*; and the coarser powder, *manna thuris*. This drug is not however, in any of its states, what is now called *thus* or *frankincense* in the shops. See the article **THUS**.

Olibanum consists of about equal parts of a gummy and resinous substance; the first soluble in water, the other in rectified spirit. With regard to its virtues, abundance have been attributed to it, particularly in disorders of the head and breast, in hæmoptoes, and in alvine and uterine fluxes: but its real effects in these cases are far from answering the promises of the recommenders. Riverius is said to have had large experience of the good effects of this drug in pleurifies, especially epidemic ones: he directs a scooped apple to be filled with a dram of olibanum, then covered and roasted under the ashes; this is to be taken for a dose, three ounces of carduus water after it, and the patient covered up warm in bed; in a short time, he says, either a plentiful sweat, or a gentle diarrhœa, ensues, which carry off the disease. Geoffroy informs us, that he has frequently made use of this medicine after venesection, with good success; but acknowledges that it has sometimes failed.

OLIGÆDRA, in natural history, the name of a genus of crystals composed of very few planes, as the name expresses. The word is compounded of *ολιγος* "a few,"

Olfactory

Oligædra.

Oligarchy few," and *ἄρα* "a plane." The bodies of this class are crystals of the imperfect kind; being composed of columns affixed irregularly to some solid body at one end, and the other terminated by a pyramid: but the column and pyramid being both pentangular, the whole consists only of ten planes, and not, as the common kind, of 12.

OLIGARCHY, a form of government wherein the administration of affairs is confined to a few hands.

OLIO, or OGLIO, a savoury dish, or food, composed of a great variety of ingredients; chiefly found at Spanish tables.

The forms of olios are various. To give a notion of the strange assemblage, we shall here add one from an approved author.

Take rump of beef, neats tongues boiled and dried, and Bologna sausages; boil them together, and, after boiling two hours, add mutton, pork, venison, and bacon, cut in bits; as also turnips, carrots, onions, and cabbage, borage, endive, marigolds, sorrel, and spinach; then spices, as saffron, cloves, mace, nutmeg, &c. This done, in another pot put a turkey or goose, with capons, pheasants, wigeons, and ducks, partridges, teals, and stock-doves, snipes, quails, and larks, and boil them in water and salt. In a third vessel, prepare a sauce of white wine, strong broth, butter, bottoms of artichokes, and chesnuts, with cauliflowers, bread, marrow, yolks of eggs, mace, and saffron. Lastly, dish the olio, by first laying out the beef and veal, then the venison, mutton, tongues, and sausages, and the roots over all; then the largest fowls, then the smallest, and lastly pour on the sauce.

OLISIPO, (Pliny, Antonine, Inscriptions); a town of Lusitania, situated on the north side of the frith of the Tagus; of such antiquity, that Solinus thought it was built by Ulysses; and Mela, probably to favour this opinion, writes, according to the common copies, *Ulyssipo*; both of them perhaps deceived by the similarity of sound. It was a municipium, with the surname *Felicitas Julia*, a privilege granted by the munificence of Augustus, (Inscriptions, Pliny). Now Lisbon, capital of Portugal, situated on the north bank of the Tagus, distant about ten miles from its mouth. See LISBON.

OLIVAREZ (Count de), by name *Don Gaspar de Guzman*, favourite and minister to Don Philip IV. of Spain, about 1620; a man of great parts and boundless ambition. Philip no sooner became king, than he became the subject of this his favourite. The king had abilities, it is true, but they lay dormant; and whilst he spent his time in listless inactivity, the whole government was under the direction of Olivarez. The count's management, indeed, was sufficiently dexterous in accomplishing his own designs; for by the best framed excuses, and on the most plausible pretexts, he removed all such as he thought stood in his way; nor did he stop there, but sometimes persecuted his rivals even to death, of which Don Rodrigo Calderona was a melancholy instance, an instance which at that time excited universal compassion. This minister, in short, had a genius of no common kind; added to which, he had a disposition which spurned all controul.

He had persecuted the late ministry for their pusillanimity in the management of affairs; he therefore thought it necessary, and it was certainly prudent, to pursue new measures. His self-sufficiency, though unbounded, was concealed under the veil of assumed modesty, and he was careful to make it appear that he was wholly taken up with the things of his own province. His politics were of a refined perhaps, but not of a very useful, tendency; for his imprudence, or his wrong notions on the subject, made him renew a war with Holland, contrary to the universal opinion of the council and the people. By the same imprudence, or by something worse, he provoked England, and obliged her to endeavour to humble the pride and lessen the authority of the house of Austria. Thus far he had been of little service to his country, having only provoked the resentment of the most powerful states, particularly England, France, Holland, &c. to conspire for its ruin. It is remarkable that Olivarez, notwithstanding this, never lost his credit; and indeed things so turned about in the end, that though Spain for a whole year was put to the severest trials, it acquired a degree of fame which sufficiently, in the general opinion, overbalanced some little loss. Olivarez too was particularly fortunate in making the peace; in which transaction he gained a very considerable advantage over Richlieu, so that things appeared to be still in a very favourable train. Fortune, however, was not always quite so indulgent to the schemes of this minister: he again drew Spain into a war with Mantua, contrary to the sentiments of the wisest men; from which is justly dated its declension, if not its ruin.

On the whole, Olivarez seems to have been always averse to peace; and with such a restless disposition, it is undoubtedly wonderful that he held his place so long and with so few complaints as he did. It was certainly owing to his ambition and obstinacy, that an almost general war was excited about the year 1627, and which, as we have said, proved so fatal to Spain. So averse, indeed, does he appear to have been to peace, that he used every means in his power to prevent the restoration of it in Italy; and for this very purpose he sent Feria into Milan, whom he knew to be a man of such a temper and abilities as suited his purposes; for he was naturally averse to quiet. He endeavoured to break the alliances of the duke of Mantua by various stratagems; but they did not succeed: the schemes of Olivarez and the intrigues of Feria being totally defeated. Our minister had soon after this another cause of mortification, on Richlieu's being created a duke and peer of France, and unanimously admitted among the Venetian nobility; which could not fail to be a severe stroke on Olivarez, who considered him as his implacable enemy.

The people at length began to see and to be displeased with his conduct; and with reason, had they known it all, for it was in many instances cruel and detestable. Indeed the differences which at that time had so long subsisted between France and Spain were the effect of the private animosity between him and Richlieu. Things, however, so turned about, and Spain was so unusually successful, that the faults of the minister were overlooked for the time; but this unexpected good fortune had no other effect than that of making him

Olivarez.

Olivarez. him far more insolent than ever. He was, in every instance, one of the most headstrong and obstinate men in the world: he had set his heart on the reduction of Casal in Italy, and he was determined on it at whatever hazard; this foolish enterprise was, however, unaccountably defeated, and the Spanish army experienced a total defeat.

The revolt of the Catalans, whom he wished to deprive of their privileges, was the next consequence of his folly: he had privately employed the Marquis de los Velez to extinguish this rebellion; but the cruelty of the measures used for this purpose only inflamed it the more. The revolution of Portugal, another disastrous event, was also the result of his obstinacy and rigour.

This series of ill fortune, which ought to have opened the eyes of the Catholic king and his ministers, seemed to infatuate both. The great secret by which Olivarez had governed his master was being the companion, or at least the confident, of his pleasures. While he affected to deceive the world with a specious appearance of religion and piety, he was not only immersed in vice himself, but encouraged and promoted it in his prince, to the scandal of his subjects, and the prejudice of his affairs. At this time, of all others the most improper, Olivarez produced a bastard of his, hitherto called *Julian*: he had taken so little care of this son, that, not able to subsist in Spain, he had passed over to the Indies, where, in very mean stations, he had scarce got bread. On him he now bestowed the name of *Don Henrico de Guzman*; and, bringing him with great pomp and splendor to court, either flattered or forced the constable of Castile to give him his daughter; in consideration of which alliance he was to devolve upon him his duchy of St Lucar. In the beginning of his administration, by some accident or other, he presented to the king a memorial, in relation to an affair upon which his majesty had already received one from *Don Balthasar de Zuniga*: upon comparing them, they contradicted each other flatly. The king ordered a person of great quality to inquire thoroughly into this business; in consequence of which *Don Balthasar's* memorial appeared to be the truth, and that of Olivarez the reverse of it. The king was very angry; but the count regained his favour, by procuring for him the fair actress *Calderona*. By this woman he had a son, of whom no great notice was taken; but now, to obscure the folly of the Conde Duke, this youth, scarce in the 14th year of his age, was produced, with the title of *Don Juan of Austria*, and declared generalissimo of the army against Portugal; while the heir apparent to the crown, *Don Balthasar*, was left under the tuition, or rather in the custody, of the countess of Olivarez; at which conduct the queen was chagrined, the people enraged, and the world in general astonished.

His schemes now began to be entirely broken and defeated everywhere and in every kind; he fell under the displeasure of the queen, the emperor, the grandees, and the people all at once, and experienced the disgrace he had long merited. His ill fortune, which came upon him with the force of a torrent, did not, however, wholly overpower him; he was indeed obliged to conceal himself, in order to avoid the rage of

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the populace; but he had still confidence enough to offer an apology for his conduct, which possessed no inconsiderable share of wit and humour, well tempered with spirited and masterly reasoning. It was not, however, of any consequence to him; for he was banished to Toro, where, worn out by infirmities, or overcome by despair, he ended his days about the year 1645.

OLIVE, in botany. See OLEA.

OLIVE-Press. In order to obtain the olive oil, the olives are first bruised in a rough trough, under a mill-stone, rolling perpendicularly over them; and when sufficiently mashed, put into the mays, or trough, *m*, of an olive-press, where *aa* are the upright beams, or cheeks; *b*, the female, and *c*, the male screw; *f*, the board on which the screw presses; *g*, a cubical piece of wood, called a *block*; *h*, the peel, a circular board, to be put under the block. By turning the screw, all the liquor is pressed out of the mashed olives, and is called *virgin-oil*; after which, hot water being poured upon the remainder in the press, a coarser oil is obtained. Olive-oil keeps only about a year, after which it degenerates.

OLIVE-Colour, a yellow mingled with black.

OLIVE (Peter John), was born in France, and died in 1297, in the fiftieth year of his age. In his youth he wrote a book in praise of the Virgin Mary, which was condemned during the pontificate of Nicholas III. as containing some things too extravagant. He afterwards was frequently accused by the brothers of his order, whose resentment he had drawn upon himself by his severe reproofs of their luxury, and his endeavours to recal them to the poverty and rigour of their first institution. After his death his body was dug up, he was condemned as a heretic, and his writings were burnt, and remained prohibited till the time of Sixtus IV. who having ordered them to be examined, declared they contained nothing expressly contrary to the Catholic faith. The propositions condemned by John are mentioned by Emmericus, in his Directory of the Inquisition, under twenty-two heads. The chief of them are, "That the Pope was the mystical antichrist; that St Francis was the angel in the Revelations said to have the mark of the living God, and that his rule was the true gospel; that the perfect state of the church began with St Francis; and that Christ and his apostles had no property either in common or in particular, but only the use-fruit of what they enjoyed."

OLIVER (Isaac), an excellent English painter, born in 1556, eminent both for history and portraits. Several fine miniatures of this master are to be seen in the collections of our nobility and gentry; some of them portraits of himself. As he was a very good designer, his drawings are finished to an extraordinary degree of perfection; many being copies after Parmegiano. Rubens and Vandyck painted James I. after a miniature of Oliver's, which is a sufficient testimony of his merit. He died in 1617.

OLIVER (Peter), the son and disciple of Isaac Oliver, was born in 1601. He arrived at a degree of perfection in miniature portraits confessedly superior to his father, or any of his contemporaries, as he did not confine his subjects to a head only. In the collections of Charles I. and James II. there were 13 historical subjects painted by this Oliver; of which seven are still preserved

Olive,
Oliver.

Plate
CCCLVII.

Olivet,
Olivetian.

preserved in the closet of queen Caroline at Kensington; and a capital painting of his wife is in the possession of the dukes of Portland. He died in 1660.

OLIVET, or *Mount of OLIVES* (anc. geog.), was situated to the east of the city of Jerusalem, and parted from the city only by the brook Kidron, and by the valley of Jehoshaphat, which stretches out from the north to the south. It was upon this mount that Solomon built temples to the gods of the Ammonites (1 Kings xi. 7.) and of the Moabites, out of complaisance to his wives, who were natives of these nations. Hence it is that the Mount of Olives is called the *mountain of corruption* (2 Kings xxiii. 13.) Josephus says, that this mountain is at the distance of five stadia, or furlongs, from Jerusalem, which make 625 geometrical paces, or the length of a Sabbath-day's journey, says St Luke (Acts i. 12.) The Mount of Olives had three summits, or was composed of three several mountains, ranged one after another from north to south. The middle summit is that from whence our Saviour ascended into heaven. It was upon that towards the south that Solomon built temples to his idols. The summit which is most to the north is distant two furlongs from the middlemost. This is the highest of the three, and is commonly called Galilee.

In the time of King Uzziah, the Mount of Olives was so shattered by an earthquake, that half of the earth that was on the western side fell down, and rolled four furlongs or 500 paces from thence, towards the mountain which was opposite to it on the east; so that the earth blocked up the highways, and covered the king's gardens.

Mr Maundrell tells us, that he and his company going out of Jerusalem at St Stephen's gate, and crossing the valley of Jehoshaphat, began immediately to ascend the mountain; that being got above two-thirds of the way up, they came to certain grottoes cut with intricate windings and caverns under ground, which were called the sepulchres of the prophets; that a little higher up were twelve arched vaults under ground, standing side by side, and built in memory of the apostles, who are said to have compiled their creed in this place; that sixty paces higher they came to the place where Christ is said to have uttered his prophecy concerning the final destruction of Jerusalem; and a little on the right hand, to another, where he is said to have dictated a second time the Lord's prayer to his disciples; that somewhat higher is the cave of a saint called *Pelagia*; a little above that a pillar, denoting the place where an angel gave the Blessed Virgin three days warning of her death; and at the top of all, the place of our Blessed Lord's ascension.

OLIVETAN (Robert), related to the famous Calvin, printed at Neufchatel in 1535, in folio, a version of the Bible into French, the first which had been translated from the original Hebrew and Greek. It is written in an uncouth and barbarous style, and is far from being faithful. The characters in which it is printed are Gothic, and the language of it is no less so. It is valued only because it is rare to be found. Calvin is thought to have had a very considerable share in this translation. Olivetan survived his publication but a short time; for he was poisoned at Rome the year after, of which his translation is alleged to have been the cause. Olivetan's Bible, revised by John Cal-

vin and N. Malingier, was reprinted at Geneva, in 1540, in quarto. This edition is still rarer than the former. It is called the *Bible de l'Epée*, because the printer had a sword for his sign.

OLIVIER (Claude Matthieu), advocate of the parliament of Aix, was born at Marseilles in 1701, and appeared at the bar with éclat. He had a chief hand in the establishment of the academy of Marseilles, and was one of its original members. He possessed a quick and lively genius. A few hours retirement from society and from his pleasures were frequently sufficient to enable him to speak and write, even on important causes; but his works commonly bore marks of haste. Given to excess in every thing, he would employ a fortnight in studying the Code and the Digest, or in storing his mind with the beauties of Demosthenes, Homer, Cicero, or Bossuet; and then abandon himself for another fortnight, frequently a whole month, to a life of frivolity and dissipation. He died in 1736, at the age of 35. He published 1. *L'Histoire de Philippe roi de Macédoine, et père d'Alexandre le Grand*, 2 vols. 12mo. No writer has so ably handled the history of the age of Philip, the interests of the different nations of Greece, and their manners and customs: but the conduct of the work is extremely defective. The digressions are too frequent, and often tedious. The style is in no respect suitable to a history. It is in general dry, unconnected, and like the style of a dissertation. Sometimes, however, we find in its passages full of fire and beauty, and turns of expression truly original. A disease of the brain, with which he was attacked, and under which he laboured several years, prevented him from putting his last hand to the work. 2. *Mémoire sur les secours donnés aux Romains par les Marseillois pendant la 2de Guerre Punique*. 3. *Mémoire sur les secours donnés aux Romains par les Marseillois durant la Guerre contre les Gaulois*.

OLMUTZ, a town in Germany, in Moravia, with a bishop's see, and a famous university. The public buildings are very handsome, particularly the Jesuits college. It is a populous, trading, and very strong place; and yet it was taken, with the whole garrison, by the king of Prussia in 1741. In July 1758 he besieged it again; and when he had almost taken the place he was obliged to raise the siege, to go and meet the Russian army. It is seated on the river Morave. E. Long. 17. 35. N. Lat. 49. 30.

OLOCENTROS, in natural history, a name given by the old Greeks to a small animal of the spider kind, whose bite was accounted mortal. It is the same with the solipuga, so called from its stinging, or biting most violently, in places, or seasons, where the sun had the most power, as Africa, &c. The name *solipuga* was a corrupt way of writing that word; and this seems also a false way of writing the word *bellocentros*, which signifies the same as solipuga.

OLYMPIA (Maldachini Donna), a woman of a very uncommon character. She flourished about the middle of the last century. She was sister-in-law to Pope Innocent X. and had the address to acquire an unlimited power over this vain, weak, and injudicious ecclesiastic. Her son Camillo was promoted to the cardinalate, under the title of Pamphilio; but falling in love with the Princess Rossana, a beautiful young widow, he laid aside his hat, and married. The crime, if it was one, was esteemed by the Romans in general at least venial.

Olivier
ll.
Olympia.

Olympia. **min.** The pope, however, was displeased; and Olympia procured their banishment, being afraid lest her daughter-in-law should lessen her authority in the *sacred court*. This authority, equally unnatural and uncommon, reflected neither honour on her who held it, nor on the man who allowed her to hold it. Such elevated situations, however, whether they are the reward of merit, the effect of chance, or acquired by cunning, are seldom very secure. Olympia, who had procured the disgrace of many who did not deserve it, and who had herself long merited such a fate, at length experienced both disgrace and banishment. This was obtained by means of cardinal Panzirollo, a great favourite of the pope's. The immediate cause of it was this: The pope had determined, in order to lessen his own trouble, to adopt a nephew, and to make him a *Cardinal Patron*, in order to give audience to ambassadors and ministers, and in his absence to preside at the council. For this purpose, at the recommendation of his favourite, his holiness made choice of Astalli, brother of the Marquis Astalli, who had married a niece of Olympia. Olympia indeed was slightly consulted on the affair, and showed no disapprobation of the appointment. The pope, however, no sooner got him fixed in his new office, than he showed his own weakness by repenting of it. Olympia too was displeased, and by her solicitations procured the disgrace of Astalli, before he had enjoyed either the honours or emoluments of his office. Panzirollo, however, soon managed matters so as to turn the scales: he prevailed on the pope again to countenance and honour Astalli; and, what was more, had influence sufficient to persuade him to disgrace Olympia, and to banish her the court. She had indeed abused her authority in a most scandalous manner, and had gained such an absolute ascendant over the pope, that in every thing his will had been subservient to her dictates. Her avarice and ambition were unbounded: she disposed of all benefices, which were kept vacant till she fully informed herself of their value: she rated an office of 1000 crowns for three years, at one year's revenue, and if for life, at 12 years purchase, one half of which sum she required to be paid in advance: she gave audience upon public affairs, enacted new laws, abrogated those of former popes, and sat in council with Innocent, with bundles of memorials in her hands. It was generally said that they lived together in a criminal correspondence, and that she had charmed him by some secret incantation. In the Protestant countries the loves and intrigues of Innocent and Donna Olympia were represented upon the stage; and severe sarcasms were daily put into the hands of Pasquin at Rome. As she had usurped such an absolute authority, the new cardinal nephew saw the necessity of ruining her credit; he therefore seconded the endeavours of Panzirollo. He insinuated to the pope, that his reputation had suffered greatly among the Catholics by her scandalous proceedings, and that his nuncios were treated with disrespect and contempt at the courts of the Emperor, France, and Spain. Upon these representations, Innocent at length, but with great reluctance, banished Olympia, and was reconciled to Prince Camillo and the Princess Rossana; though some authors affirm that her banishment was no more than a political retreat, and that she still in private directed the affairs of the pope. A woman of Olympia's character, however, with such un-

bounded ambition, such an extravagant lust for power, Olympia. and such an ambitious desire of wealth, and who had once possessed so great an ascendancy over such a man as Innocent, was not to be so easily put off. She was banished in 1650; but in 1653, she again assumed the supreme direction of affairs just as before her disgrace. She again accomplished the disgrace of Astalli, and procured the promotion of Azzolini to the office of secretary of the briefs. In 1654, his holiness resigned himself entirely into the hands of this assuming woman; who, observing his infirmities daily increasing, redoubled her rapacity, disposing of benefices to the highest bidders in all parts of Italy. She was again, however, in hazard of being displaced by a new favourite, viz. the Cardinal de Retz; and had not the pope's dissolution prevented it, it would in all probability quickly have taken place. During his last illness he received nothing but from the hands of Donna Olympia, who was at great pains to prolong his life, watched continually at his bed-side, and prevented the ambassadors or others from disturbing him with discourses upon business. She is said, during the last ten days of his life, when he continued without the use of reason, to have amassed about half a million of crowns. She did not find the succeeding pope (Alexander VII.) so easy to be played upon as his weak predecessor: a number of memorials were sent in against her, and his holiness was well disposed to attend to them; he ordered her to retire from Rome, and at the same time began to examine witnesses respecting her conduct. She was cut off, however, before the trial was finished, by the plague, which, in 1636, afflicted Rome and its neighbourhood. Her estate was not confiscated as was generally expected; and the prince Pamphilio was allowed to succeed her. The pope only reserved for his own relations about a million of crowns.

OLYMPIA (anc. geog.), with the surname *Pisatis* (Strabo); so called from the territory of Pisa in Elis; described by Strabo, "as the temple of Jupiter Olympius, before which stands a grove of wild olive-trees, in which is the stadium, or foot-course, so called because the eighth part of a mile; and by which the Alpheus, coming down from Arcadia, runs." Olympia, however, was famous, not merely for the temple of Jupiter, but also for a temple of Juno, 63 feet long, with columns round it of the Doric order; and a Metroum or temple of the mother of the gods, a large Doric edifice; with holy treasuries. These, and the porticoes, a gymnasium, prytaneum, and many more buildings, chiefly in the enclosure, with the houses of the priests and other inhabitants, made Olympia no inconsiderable place. The stadium was in the grove of wild olive-trees, before the great temple; and near it was the hippodrome or course for the races of horses and chariots. The Alpheus flowed by from Arcadia with a copious and very pleasant stream, which was received on the coast by the Sicilian sea.

The temple of Jupiter was of the Doric order, 68 feet high to the pediment, 95 wide, and 230 long; the cell encompassed with columns. It was erected with the country-stone; the roof, not of earth baked, but of Pentelic marble; the slabs disposed as tiles; the way to it up a winding staircase. The two pediments were enriched with sculpture; and one had over the centre a statue of Victory gilded, and underneath a votive

Olympia. buckler of gold. At each corner was a gilded vase. Above the columns were fixed 21 gilded bucklers, offered at the conclusion of the Achæan war by the Roman general Mummius. The gates in the two fronts were of brass, and over them were carved the labours of Hercules. Within the cell were double colonnades, between which was the approach to the image.

The Jupiter of Olympia was accounted alone sufficient to immortalize its maker, Phidias. It was of ivory and gold, the head crowned with olive. In the right hand was a statue of Victory; in the left a flowered sceptre, composed of various metals, on which was an eagle. The sandals were of gold, as also the vestment, which was curiously embossed with lilies and animals. The throne was gold inlaid with ebony and ivory, and studded with jewels, intermixed with paintings and exquisite figures in relief. The pillars between the feet contributed to its support. Before it were walls, serving as a fence, decorated principally with the exploits of Hercules; the portion opposite to the door of a blue colour. It was the office of a family descended from Phidias, called *phædruntæ* or *the polishers*, to keep the work bright and clean. The veil or curtain was cloth rich with the purple dye of Phœnicia and with Assyrian embroidery, an offering of king Antiochus, and was let down from above by looping the strings. The image impressed on the spectator an opinion that it was higher and wider than it measured. Its magnitude was such, that though the temple was very large, the artist seemed to have erred in the proportions. The god, sitting, nearly touched the ceiling with his head; suggesting an idea, that if he were to rise up, he would destroy the roof. A part of the pavement before it was of black marble, enclosed in a rim of Parian or white, where they poured oil to preserve the ivory.

The altar of Jupiter Olympius was of great antiquity, and composed of ashes from the thighs of the victims, which were carried up and consumed on the top with wood of the white poplar-tree. The ashes also of the prytæneum, in which a perpetual fire was kept on a hearth, were removed annually on a fixed day, and spread on it, being first mingled with water from the Alpheus. The cement, it was affirmed, could be made with that fluid only; and therefore this river was much respected, and esteemed the most friendly of any to the god. On each side of the altar were stone-steps. Its height was 22 feet. Girls and women, when allowed to be at Olympia, were suffered to ascend the basement, which was 125 feet in circumference. The people of Elis sacrificed daily, and private persons as often as they chose.

Religion flourished at Olympia, and many deities were worshipped besides Jupiter. Pausanias has enumerated above 60 altars of various shapes and kinds. One of the unknown gods stood by the great altar. The people of Elis offered on all these monthly; laying on them boughs of olive; burning incense, and wheat mixed with honey; and pouring libations of such liquors as the ritual prescribed. At the latter ceremony sometimes a form of prayer was used, and they sung hymns composed in the Doric dialect.

Olympia was situated on an eminence, between two mountains called *Offa* and *Olympus*. Though its ancient splendor is gone, the place reminds the traveller of

of what it once was. It is in the Marca, being now a small place called *Longinico*, 50 miles south of Lepanto, in E. Long. 22. 0. N. Lat. 37. 40. Olympiad,
Olympias.

OLYMPIAD, the space of four years, whereby the Greeks reckoned time.—The first Olympiad fell, according to the accurate and learned computation of some of the moderns, exactly 776 years before the first year of Christ, or 775 before the year of his birth, in the year of the Julian period 3938, and 22 years before the building of the city of Rome. The games were exhibited at the time of the full moon next after the summer solstice; therefore the Olympiads were of unequal length, because the time of the full moon differs 11 days every year, and for that reason they sometimes began the next day after the solstice, and at other times four weeks after. The computation by Olympiads ceased, as some suppose, after the 364th, in the year 440 of the Christian era. It was universally adopted not only by the Greeks, but by many of the neighbouring countries; though still the Pythian games served as an epoch to the people of Delphi and to the Bœotians; the Nemæan games to the Argives and Arcadians; and the Isthmian to the Corinthians and the inhabitants of the Peloponnesian isthmus. To the Olympiads history is much indebted. They have served to fix the time of many momentous events; and indeed before this method of computing time was observed, every page of history is mostly fabulous, and filled with obscurity and contradiction, and no true chronological account can be properly established and maintained with certainty.

OLYMPIAS, a celebrated woman, who was daughter of a king of Epirus, and who married Philip king of Macedonia, by whom she had Alexander the Great. Her haughtiness, and more probably her infidelity, obliged Philip to repudiate her, and to marry Cleopatra, the niece of King Attalus. Olympias was sensible of this injury, and Alexander showed his disapprobation of his father's measures, by retiring from the court to his mother. The murder of Philip, which soon followed this disgrace, and which some have attributed to the intrigues of Olympias, was productive of the greatest extravagances. The queen paid the greatest honour to her husband's murderer. She gathered his mangled limbs, placed a crown of gold on his head, and laid his ashes near those of Philip. The administration of Alexander, who had succeeded his father, was in some instances offensive to Olympias; but when the ambition of her son was concerned, she did not scruple to declare publicly that Alexander was not the son of Philip, but that he was the offspring of an enormous serpent who had supernaturally introduced himself into her bed. When Alexander was dead, Olympias seized the government of Macedonia; and, to establish her usurpation, she cruelly put to death Aridæus, with his wife Eurydice, as also Nicanor the brother of Cassander, with 100 leading men of Macedon, who were inimical to her interest. Such barbarities did not long remain unpunished: Cassander besieged her in Pydna, where she had retired with the remains of her family, and she was obliged to surrender after an obstinate siege. The conqueror ordered her to be accused, and to be put to death. A body of 200 soldiers were ordered to put the bloody commands into execution, but the

Olympic. splendor and majesty of the queen disarmed their courage; and she was at last massacred by those whom she had cruelly deprived of their children, about 316 years before the Christian era.

* Gilles's
History of
Greece.

OLYMPIC GAMES, were solemn games among the ancient Greeks, so called from Olympian Jupiter, to whom they were dedicated; and by some said to be first instituted by him, after his victory over the sons of Titan; others ascribe their institution to Hercules, not the son of Alcmena, but one of much greater antiquity; others to Pelops; and others to Hercules the son of Alcmena. By whomsoever they were instituted, we know that, at a period rather early, they had fallen into disuse. The wars which prevailed among the Greeks, for a while, totally interrupted the religious ceremonies and exhibitions with which they had been accustomed to honour the common gods and heroes; but the Olympic games were restored on the following occasion. Amidst the calamities which afflicted or threatened Peloponnesus, Iphitus, a descendant of Oxylus, to whom the province of Eleia * had fallen in the general partition of the peninsula, applied to the Delphic oracle. The priests of Apollo, ever disposed to favour the views of kings and legislators, answered agreeably to his wish, that the festivals anciently celebrated at Olympia, on the Alpheus, must be renewed, and an armistice proclaimed for all the states willing to partake of them, and desirous to avert the vengeance of heaven. Fortified by this authority, and assisted by the advice of Lycurgus, Iphitus took measures, not only for restoring the Olympic solemnity, but for rendering it perpetual. The injunction of the oracle was speedily diffused through the remotest parts of Greece by the numerous votaries who frequented the sacred shrine. The armistice was proclaimed in Peloponnesus, and preparations were made in Eleia for exhibiting shows and performing sacrifices. In the heroic ages, feats of bodily strength and address were destined to the honour of deceased warriors; hymns and sacrifices were reserved for the gods: but the flexible texture of Grecian superstition, easily confounding the expressions of respectful gratitude and pious veneration, enabled Iphitus to unite both in his new institution.

The festival, which lasted five days, began and ended with a sacrifice to Olympian Jove. The intermediate time was chiefly filled up by the gymnastic exercises, in which all freemen of Grecian extraction were invited to contend, provided they had been born in lawful wedlock, and had lived untainted by any infamous immoral stain. The preparation for this part of the entertainment was made in the gymnasium of Elis, a spacious edifice, surrounded by a double range of pillars, with an open area in the middle. Adjoining were various apartments, containing baths, and other conveniences for the combatants. The neighbouring country was gradually adorned with porticoes, shady walks and groves, interspersed with seats and benches; the whole originally destined to relieve the fatigues and anxiety of the candidates for Olympic fame; and frequented, in later times, by sophists and philosophers, who were fond to contemplate wisdom, and communicate knowledge, in those delightful retreats. The order of the athletic exercises, or combats, was established by Lycurgus, and corre-

sponded almost exactly to that described by Homer, in the 23d book of the Iliad, and eighth of the Odyssey. Iphitus, we are told, appointed the other ceremonies and entertainments; settled the regular return of the festival at the end of every fourth year, in the month of July; and gave to the whole solemnity that form and arrangement, which it preserved with little variation above a thousand years; a period exceeding the duration of the most famous kingdoms and republics of antiquity. Among the benefactors of Olympia, at a much later period, was reckoned Herod, who was afterwards king of Judæa. Seeing, on his way to Rome, the games neglected or dwindling into insignificance from the poverty of the Eleans, he displayed vast munificence as president, and provided an ample revenue for their future support and dignity.

The care and management of the Olympics belonged for the most part to the Eleans; who on that account enjoyed their possessions without molestation, or fear of war or violence. They appointed a certain number of judges, who were to take care that those who offered themselves as competitors should perform their preparatory exercises; and these judges, during the solemnity, sat naked, having before them a crown of victory, formed of wild olive, which was presented to whomsoever they adjudged it. Those who were conquerors were called *Olympionices*, and were loaded with honours by their countrymen. At these games women were not allowed to be present; and if any woman was found, during the solemnity, to have passed the river Alpheus, she was to be thrown headlong from a rock. This, however, was sometimes neglected; for we find not only women present at the celebration, but also some among the combatants, and some rewarded with the crown. The preparations for these festivals were great. No person was permitted to enter the lists if he had not regularly exercised himself ten months before the celebration at the public gymnasium of Elis. No unfair dealings were allowed; whoever attempted to bribe his adversary was subjected to a severe fine; and even the father and relations were obliged to swear that they would have recourse to no artifice which might decide the victory in favour of their friends. No criminals, nor such as were connected with impious and guilty persons, were suffered to present themselves as combatants. The wrestlers were appointed by lot. Some little balls superscribed with a letter were thrown into a silver urn, and such as drew the same letter were obliged to contend one with the other. He who had an odd letter remained the last; and he often had the advantage, as he was to encounter the last who had obtained the superiority over his adversary. In these games were exhibited running, leaping, wrestling, boxing, and the throwing of the quoit, which was called altogether *πενταθλον*, or *quinqertium*. Besides these, there were horse and chariot races, and also contentions in poetry, eloquence, and the fine arts. The only reward that the conqueror obtained was a crown of olive. This, as some suppose, was in memory of the labours of Hercules, which were accomplished for the universal good of mankind, and for which the hero claimed no other reward but the consciousness of having been the friend of mankind. So small and trifling a reward stimulated courage and virtue, and was the source of greater

Olympic.

Olympic. greater honours than the most unbounded treasures. The statues of the conquerors, called *Olympionicae*, were erected at Olympia in the sacred wood of Jupiter. Their return home was that of a warlike conqueror; they were drawn in a chariot by four horses, and everywhere received with the greatest acclamations. Their entrance into their native city was not through the gates; to make it more grand and more solemn a breach was made in the walls. Painters and poets were employed in celebrating their names; and indeed the victories severally obtained at Olympia are the subjects of the most beautiful odes of Pindar. The combatants were naked. A scarf was originally tied round their waist; but when it had entangled one of the adversaries, and been the cause that he lost the victory, it was laid aside, and no regard was paid to decency. The Olympic games were observed every fifth year, or, to speak with greater exactness, after a revolution of four years, and in the first month of the fifth year, and they continued for five successive days. As they were the most ancient and most solemn of all the festivals of the Greeks, it will not appear wonderful that they drew so many people, not only inhabitants of Greece, but of the neighbouring islands and countries.

Such is the account of Grecian writers, who have, doubtless, often ascribed to positive institution many inventions and usages naturally resulting from the progressive manners of society. When we come to examine the Elean games in their more improved state, together with the innumerable imitations of them in other provinces of Greece, there will occur reasons for believing, that many regulations, referred by an easy solution to the legislative wisdom of Iphitus or Lycurgus, were introduced by time or accident, continued thro' custom, improved by repeated trials, and confirmed by a sense of their utility*. Yet such an institution as the Olympiad, even in its least perfect form, must have been attended with manifest advantages to society. It is sufficient barely to mention the suspension of hostilities which took place, not only during the celebration of the festival, but a considerable time both before and after it. Considered as a religious ceremony, at which the whole Grecian name was invited, and even enjoined, to assist, it was well adapted to facilitate intercourse, to promote knowledge, to soften prejudice, and to hasten the progress of civilisation and humanity. Greece, and particularly Peloponnesus, was the centre from which the adventurous spirit of its inhabitants had diffused innumerable colonies through the surrounding nations. To these widely separated communities, which, notwithstanding their common origin, seemed to have lost all connection and correspondence, the Olympiad served as a common bond of alliance and point of reunion. The celebrity of this festival continually attracted to it the characters most distinguished for genius and enterprise, whose fame would have otherwise been unknown and lost in the boundless extent of Grecian territory. The remote inhabitants, not only of European Greece, but of Asia and Africa, being assembled to the worship of common gods, were formed to the sense of a general interest, and excited to the pursuit of national honour and prosperity. Strangers of similar dispositions might confirm in Elis the sacred and indissol-

uble ties of hospitality. If their communities were endangered by any barbarous power, they might here solicit assistance from their Grecian brethren. On other occasions they might explain the benefits which, in peace or war, their respective countries were best qualified to communicate. And the Olympic festival might thus serve the purpose of resident ambassadors, and other institutions alike unknown to antiquity.

OLYMPUS, the name of several mountains.—One bounding Bithynia on the south.—Another in the island of Cyprus, on whose top was a temple of Venus, which women were not permitted either to enter or to see (Strabo).—A third, Olympus of Galatia (Livy).—A fourth, of Lycia, with a noble cognominal town, near the sea-coast (Strabo, Cicero), extinct in Pliny's time, there remaining only a citadel: the town was destroyed by P. Servilius Isauricus (Florus), having been the retreat of pirates. From this mountain there was an extensive prospect of Lycia, Pamphylia, and Pisidia (Strabo).—A fifth, Olympus of Mysia (Ptolemy); thence surnamed *Olympena*, anciently *Minor*; one of the highest mountains, and surnamed *Mysus* (Theophrastus); situated on the Propontis, and thence extending more inland.—A sixth, on the north of Thessaly, or on the confines of Macedonia; famous for the fable of the giants (Virgil, Horace, Seneca); reckoned the highest in the whole world, and to exceed the flight of birds (Apuleius); which is the reason of its being called *heaven*, than which nothing is higher: the serenity and calmness which reign there are celebrated by Homer, Lucan, and Claudian.

OLYRA, in botany: A genus of the triandria order, belonging to the nœcia class of plants; and in the natural method ranking under the 4th order, *Gramina*. The male calyx is a biflorous and aristated glume; the corolla a beardless glume; the female calyx is an uniflorous, patulous, and ovate glume; the style is bifid, and the seed cartilaginous.

OMAR (Ebn Al Khattab) successor of Abu Beer.—The Mohammedan imposture, like every other falsehood of its kind, copies after the truth as far as was thought convenient or proper; and miracles being the grand proof of revelation, it was to be expected that all pretences to that should assume at least the appearances of them. Few systems of faith are more absurd than Mohammed's; yet, though he disclaimed miracles, it was supported, as we are told by latter writers, by a variety of them, which, however unfortunately for the creed they were contrived to support, are too trifling, absurd, and contradictory, to deserve the smallest attention.

They tell us, but upon grounds too vague and indeterminate to command belief, that Omar was miraculously converted to this faith; a man he is reported to have been, before this event, truly respectable, and in particular a violent opposer of the Arabian prophet. Mohammed, it seems, felt this opposition and regretted it; he therefore, with the fervour, and, as it happened, with the success of a true prophet, according to his followers account, prayed for the conversion of this his dangerous antagonist. Omar, it is said, had no sooner read the 20th chapter of the Koran than he was convinced: upon which he instantly repaired to Mohammed and his followers, and declared his conversion. It is said, that at one time he intended to

Olympus
Omar.

* Gilles's
History of
Greece.

Omar

murder the prophet; and various causes are assigned for the prevention of this shocking piece of sacrilege. After his wonderful conversion, the Mohammedan writers inform us that he was surnamed *Al Faruk*, or the "divider;" because, say they, when a certain Moslem was condemned by Mohammed for his iniquitous treatment of a Jew, and appealed afterwards from the sentence of the prophet to Omar, he cut him in two with his scimitar, for not acquiescing in the decision of so upright a judge: which circumstance when Mohammed heard, he gave him the surname of *Al Faruk*, or "the divider;" because, by this action, he had shown himself capable of perfectly distinguishing between truth and falsehood. Al Kodai affirms, that 39 of Omar's adherents followed his example the same day he professed himself a votary of Mohammed. The conversion of Hamza and Omar Ebn Al Khattab happened in the year preceding the first flight of the Moslems into Ethiopia, or the fourth year of Mohammed's mission, according to Abulfeda. He was unquestionably a great acquisition to the prophet, and enabled him to carry on his schemes to far more purpose than he could possibly have done without him, or if he had continued his enemy. Omar at length found his services in the cause he had undertaken sufficiently honoured and amply rewarded; for on the death of Abu Beer, who had succeeded the impostor himself, he was promoted to the regal and pontifical dignity. The title first assigned him was the *khalif of the khalif of the apostle of God*; or in other words *the successor of the successor of Mohammed*: but the Arabs considering that this title, by the addition to be annexed to it at the accession of every future khalif, would be too long, they, by universal consent, saluted him *the emperor of the believers*. Which illustrious title, at this juncture conferred on Omar, descended afterwards to all the successors of that prince. Our readers will not expect us to follow the khalif with minute exactness through the transactions of his reign. This would indeed swell our article beyond all proportion. We shall therefore confine ourselves to some of the leading facts.

His arms appear to have been particularly successful; the Persians he conquered, and Jerusalem submitted to his power; nor does he appear to have been checked in a single instance. In consequence, however, of his success, an attempt was made to assassinate him. The fact is thus related: Wathek Ebn Mosafer, a resolute young Arab, was procured by the king of Ghafsan, and sent to Medina for this very purpose. Some time after his arrival, observing Omar to fall asleep under a tree on which he had placed himself, so as not to be discovered by any person, he drew his dagger, and was upon the point of stabbing him, when, lifting up his eyes, he saw a lion walking round about him, and licking his feet. Nor did the lion cease to guard the khalif till he awoke; but then instantly went away. This phenomenon struck Wathek with a profound reverence for Omar, whom he now revered as the peculiar care of heaven. He therefore came down from the tree, on which the lion had forced him to remain, kissed the khalif's hand, confessed his crime, and embraced the Mohammedan religion; being so strongly affected with the wonderful deliverance he had been an eye-witness of. His life, however, was

at length ended by assassination; for about two years after the conclusion of the Nohawandian war, in which the Arabs probably still farther extended their conquests, though no account of their military operations during that period has reached us, that is, in the 23d year of the Hegira, according to Abu Jaafar Al Tabari, the khalif Omar Ebn Al Khattab was assassinated by a Persian slave; of which horrid fact the Arab writers have handed down the following particulars: Abu Lulua, a Persian of the Magian sect, whose name was *Firuz*, one of Al Mogheira Ebn Al Shaabah's slaves, was obliged by his master to pay daily two dirhems, in conformity to the Mohammedan custom, for the free exercise of his religion. Firuz resenting this treatment, complained of it to the khalif, and desired that some part at least of the tribute exacted of him might be remitted; but this favour being refused by Omar, the Persian threatened his destruction; which he soon after effected, by stabbing him thrice in the belly with a dagger, whilst he was in the mosque at Medina performing his morning devotions. The Arabs then present perceiving that the villain had embroiled his hands in the blood of their sovereign, immediately rushed upon him; but he made so desperate a defence, that he wounded 13 of the assailants, and seven of them mortally. At last, one of the khalif's attendants threw his vest over him, and seized him; upon which he stabbed himself, and soon after expired. According to Theophanes, this Firuz was an apostate or renegade, and consequently had before embraced the Mohammedan religion: but this assertion is by no means probable; because, on his becoming a convert to Islamism, he must have been manumitted by his master, and on his relapsing into Magism, he would have been put to death by the khalif's order: neither of which particulars are consistent with what we find related by the Arab historians, and even by our Greek chronographer himself. Omar languished three days, and then died, in the month of Dhu'lhajja, and the 23d year of the Hegira, which began in the year of our Lord 643. Authors are not agreed with regard to the duration of his khalifat. The Arab historians, whom we are inclined to follow, say that he reigned between 10 and 11 years. Theophanes affirms, that he was murdered in the 12th year of his khalifat, and Dionysius Telmarenis extends the length of his reign to 12 complete years. Only one of the wounds given him by Firuz was mortal, and that he received under his navel. At his death he was 63 years old; which, as we are told by an Arab author, was the age of Mohammed himself, Abu Beer, and Ayesha, one of the prophet's wives, when they died. When Omar fell in the mosque, Abd'alahman Ebn Awf, one of Mohammed's first converts, supplied his place during the remainder of the service; and three days before his death, Sahib Ebn Tarif, at his command, officiated for him. His body was interred in Ayesha's apartment, near that of the prophet Mohammed. We are informed by Eutychius, that during his khalifat he performed the pilgrimage to Mecca nine times. His extensive conquests made the Moslem empire one of the most powerful and formidable monarchies in the world. His disposition is represented to us, with evident partiality indeed,

Omar

Ombi.

as one of the best possible, and his temperance has always been highly extolled.

OMBI, a city of ancient Egypt, afterwards called *Arfinoe* and *Crocodilopolis*, was the capital of one of the nomes into which that country was divided, and is remarkable, in the annals of idolatry, for the hatred of its inhabitants to the religion of their neighbours the citizens of Tentyra.

The genius of paganism was so complying with respect to the objects of religious worship, that although each nation, each city, and almost every family, had its own tutelary god, we know not a single instance, out of Egypt, of one tribe of pagans persecuting another for worshipping gods different from theirs. The Jews and Christians were indeed persecuted by the Romans, not however for worshipping the true God, but because, together with him, they would not worship Jupiter, Juno, and all the rabble of heathen divinities.

The reason of the almost universal tolerance of idolaters to one another, and of the intolerance of all to the Jews and Christians, is very obvious. Not a single pagan, a very few philosophers perhaps excepted, ever thought of paying his adoration to the Supreme and self-existent Being, but to inferior divinities, to whom it was supposed that the care of particular persons, families, cities, and nations was consigned by the God of the universe. The consequence was, that, as no person denied the divinity of his neighbour's object of worship, an intercommunity of gods was every where admitted, and all joined occasionally in adoring the gods of the various nations. By the Jews and Christians this communion was rejected as in the highest degree impious; and it could not well be maintained between the citizens of Ombi and those of Tentyra.

That brutes were worshipped in Egypt is universally known (See POLYTHEISM); and Diodorus the Sicilian informs us, in a passage quoted by Eusebius*, that "the cities and nomes of Egypt being at one time prone to rebellion, and to enter into conspiracies against monarchical government, one of their most politic kings contrived to introduce into the neighbouring nomes the worship of different animals; so that while each revered the deity which itself held sacred, and despised that which its neighbours had consecrated, they could hardly be brought to join cordially in one common design to the disturbance of the government."

In this distribution of gods he conferred upon Ombi the *crocodile*, and upon Tentyra the mortal enemy of that monster, the *ichneumon*. The consequence of which was, that while the Ombites worshipped the crocodile, the Tentyrites took every opportunity of slaughtering him, inasmuch that, according to Strabo, the very voice of an inhabitant of Tentyra put the crocodile to flight. This, we confess, is a very improbable fact; but it is certain that the mutual hatred of those cities, on account of their hostile gods, rose to such a height, that whenever the inhabitants of the one were engaged in the more solemn rites of their religion, those of the other were sure to embrace the opportunity of setting fire to their houses, and rendering them every injury in their power to inflict. And what may, to a superficial thinker, appear extraordinary, though it will excite no wonder in the breast

Nº 246.

of him who has studied mankind, this animosity continued between the inhabitants of the two cities long after the crocodile and ichneumon had lost their divinity.

The conduct of the Egyptian monarch was admirably calculated for preventing the nation from combining against the government; and it extended its influence over the whole kingdom. Diodorus informs us, that he assigned to each nome an animal to worship, which was hated, killed, and sometimes fed upon by the inhabitants of the neighbouring nome; and we know upon higher authority than his, that the Israelites could not offer sacrifices in Egypt, because the bullock was deemed sacred over the whole country.

OMBRE, a celebrated game at cards, borrowed from the Spaniards, and played by two, by three, or by five persons, but generally by three. When three play at this game, nine cards are dealt to each party; the whole ombre pack being only 40; because the eights, nines, and tens are thrown out of the pack. There are two sorts of counters for stakes, the greater and the lesser; the last having the same proportion to the other as a penny to a shilling: of the greater counters each man stakes one for the game; and one of the lesser for passing for the hand, when eldest, and for every card taken in. As to the order and value of the cards, the ace of spades, called *spadillo*, is always the highest trump, in whatsoever suit the trump be; the *manille*, or black duce, is the second; and the *baslo*, or ace of clubs, is always the third: the next in order is the king, the queen, the knave, the seven, the six, the five, four, and three. Of the black there are 11 trumps; of the red, 12. The least small cards of the red are always the best, and the most of the black; except the duce and red seven, both of which are called the *manilles*, and are always second when the red is a trump. The red ace, when a trump, enters into the fourth place, and is called *punto*, otherwise it is only called an *ace*. The three principal cards are called *matadores*; which have this privilege, that they are not obliged to attend an inferior trump when it leads; but for want of a small trump, the person may renounce trumps, and play any other card; and when these are all in the same hand, the others pay three of the greater counters a-piece; and with these three for a foundation, he may count as many matadores as he has cards in an uninterrupted series of trumps; for all which the others are to pay one counter a-piece. He who hath the first hand is called *ombre*, and has his choice of playing the game, of naming the trump, and of taking in as many and as few cards as he pleases; and after him the second, &c. But if he does not name the trump before he looks on the cards he has taken in, any other may prevent him, by naming what trump he pleases. He that has the first hand should neither take in, nor play, unless he has at least three sure tricks in his hand: for, as he wins the game who wins most tricks, he that can win five of the nine has a sure game; which is also the case if he wins four, and can so divide the tricks as that one person may win two, and the other three.

If a person plays without discarding or changing any cards, this is called *playing sans prendre*; and if another wins more tricks than he, he is said to *win co-dille*. The over-sights in the course of the game are called

Ombre.

* Prep.
Evang.
P. 32.
Steph. ed.

Ombre called *beasts*. And if the ombre wins all the nine tricks, it is called *winning the vole*.

Ombre by five, which many, on account of its not requiring so close an attention, prefer to that by three, only eight cards a-piece are dealt; and five tricks must be won, otherwise the ombre is *beasted*. Here the person who undertakes the game, after naming the trump, calls a king to his assistance; upon which the person in whose hand the king is, without discovering himself, is to assist him as a partner, and to share his fate. If, between both, they can make five tricks, the ombre wins two counters, and the auxiliary king only one; but when the counters are even, they divide them equally. If the ombre venture the game without calling in any king, this too is called *playing sans prendre*; in which case the other four are all against him, and he must win five tricks alone, or be *beasted*. The rest is much the same as by three.

OMBRE de soleil. "Shadow of the sun," in heraldry, is when the sun is borne in armory, so as that the eyes, nose, and mouth, which at other times are represented, do not appear; and the colouring is thin, so that the field can appear through it.

OMBRIA, the ancient name of a province of Italy, in the territory of the pope, now called *Spoletto* and *Perugia*.

OMBRO, or LOMBRO, a town of Italy, in the duchy of Tuscany, and territory of the Siennois, situated near the Tuscan sea, a little south of the lake of Castiglione, 45 miles south-west of Sienna.

OMBROMETER, a machine to measure the quantity of rain that falls. We have the description and sign of one in *Phil. Trans.* n^o 473. p. 12. It consists of a tin-funnel, whose surface is an inch square, with a flat board, and a glass-tube set into the middle of it in a groove. The rise of the water in the tube, whose capacity at different times must be measured and marked, shows the quantity of rain that has fallen.

OMELET, or AMLET, a kind of pancake or fricasse of eggs, with other ingredients, very usual in Spain and France. It may be made as follows: The eggs being beaten, are to be seasoned with salt and pepper, and then fried in butter made boiling hot; this done, gravy is to be poured on, and the whole stewed with chives and parsley sliced small: when one side is fried enough, it is to be turned on the other.

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OMEN, is a word which, in its proper sense, signifies a sign or indication of some future event taken from the language of a person speaking without any intent to prophecy. Hence Tully says, "Pythagorei non solum voces deorum observarunt, sed etiam hominum, quæ vocent *omina*;" "the Pythagoreans attend to the discourse not only of gods, but also of men, which they call *omens*." This sort of omen was supposed to depend much upon the will of the person concerned in the event; whence the phrases *accepit omen*, *arripuit omen*. Such were the original *omens*; but they were afterwards derived from *things* as well as from words. Thus Paterculus, speaking of the head of Sulpicius on the rostrum, says, it was *velut omen imminentis proscriptionis*, "the omen of an impending proscription." Suetonius says of Augustus, that he believed implicitly in certain *omens*; and that, *si manesibi calceus perperam, ac sinister pro dextero induceretur, ut dirum*, "if his shoes were improperly put on in the morning, especially if the left shoe was put upon his right foot, he held it for a bad omen." Omen was used in a still larger sense, to signify an *augury*; as in the following line of Tully: "Sic aquilæ clarum firmavit Jupiter *omen*;" "thus Jove confirmed the bright omen of the eagle." It was lastly used, in the most generic sense of all, for a portent or prodigy; as in the third book of the *Æneid*, where a myrtle torn up by Æneas dropped blood. Upon this appearance, says the hero,

Omen.

— — — Mihi frigidus horror

Membra quatit, gelidusque coit formidine sanguis.

And the same thing being repeated upon his breaking a branch from another tree, he prayed to the gods to avert the *omen*.

Multa movens animo Nymphas venerabar agrestes,
Gradivumque patrem, Geticis qui præfidet arvis,
Rite secundarent visus, *omenque* levarent (A).

These portentous or supernatural omens were either external or internal. Of the former sort were those showers of blood so frequently occurring in the Roman history, which were much of the same nature with this adventure of Æneas, which he calls *MONSTRA DEUM*. Of the second sort were those sudden consternations, which, seizing upon men without any visible cause, were imputed to the agency of the god *Pan*, and hence called *panic fears*. But indeed there was

D d

hardly

(A) Instead of translating these short quotations, we shall here give Dryden's version of the whole of this portentous adventure, as we are persuaded that the mere English reader, who alone can wish for a translation, will be glad to have the fullest account of the bleeding myrtle, together with its effects on the mind of the hero. It is as follows:

Not far, a rising hillock stood in view;
Sharp myrtles on the sides and corners grew.
There, while I went to crop the sylvan scenes,
And shade our altar with their leafy greens,
I pull'd a plant (with horror I relate
A prodigy so strange, and full of fate):
The rooted fibres rose; and from the wound
Black bloody drops distill'd upon the ground.
Mute and amaz'd, my hair with terror stood;

Fear shrunk my sinews, and congeal'd my blood.
Mann'd once again, another plant I try;
That other gush'd with the same sanguine dye.
Then, fearing guilt for some offence unknown,
With prayers and vows the Dryads I atone,
With all the sisters of the woods, and most
The God of arms, who rules the Thracian coast:
That they, or he, these omens would avert,
Release our fears, and better signs impart.

Omen.

hardly any thing, however trivial, from which the ancients did not draw omens. That it should have been thought a direful omen when any thing befel the temples, altars, or statues of the gods, need excite no wonder; but that the meeting of a eunuch, a negro, a bitch with whelps, or a snake lying in the road, should have been looked upon as portending bad fortune is a deplorable instance of human weakness, and of the pernicious influence of superstition on the mind.

It is more than probable that this practice of making ordinary events ominous of good or bad fortune took its rise in Egypt, the parent country of almost every superstition of paganism; but wherever it may have arisen, it spreads itself over the whole inhabited globe, and at this day prevails in a greater or less degree among the vulgar of all nations.

In England, it is reckoned a good omen, or a sign of future happiness, if the sun shines on a couple coming out of the church after having been married. It is also esteemed a good sign if it rains whilst a corpse is burying:

Happy is the bride that the sun shines on;
Happy is the corpse that the rain rains on.

To break a looking-glass is extremely unlucky; the party to whom it belongs will lose his best friend.

If, going a journey on business, a sow crosses the road, you will probably meet with a disappointment, if not a bodily accident, before you return home. To avert this, you must endeavour to prevent her crossing you; and if that cannot be done, you must ride round on fresh ground. If the sow is attended with her litter of pigs, it is lucky, and denotes a successful journey.

It is unlucky to see, first one magpye, and then more; but to see two, denotes marriage or merriment; three, a successful journey; four, an unexpected piece of good news; five, you will shortly be in a great company. To kill a magpye, will certainly be punished with some terrible misfortune.

If, in a family, the youngest daughter should be married before her elder sisters, they must all dance at her wedding without shoes: this will counteract their ill luck, and procure them husbands.

If you meet a funeral procession, or one passes by you, always take off your hat: this keeps all evil spirits attending the body in good humour.

If, in eating, you miss your mouth, and the victuals fall, it is very unlucky, and denotes approaching sickness.

It is lucky to put on a stocking the wrong side outwards: changing it, alters the luck.

When a person goes out to transact any important business, it is lucky to throw an old shoe after him.

It is unlucky to present a knife, scissors, razor, or any sharp or cutting instrument, to one's mistress or friend, as they are apt to cut love and friendship. To avoid the ill effects of this, a pin, a farthing, or some trifling recompense, must be taken. To find a knife or razor, denotes ill luck and disappointment to the party.

In the Highlands of Scotland, it is thought unlucky if a person setting out upon a journey stumble over

the threshold, or be obliged to return for any thing forgotten. If a sportsman see any person stepping over his gun or fishing-rod, he expects but little success in that day's diversion. *Sneezing* is also deemed ominous. If one sneeze when making a bed, a little of the straw or heath is taken out and thrown into the fire, that nothing may disturb the rest of the person who is to sleep in the bed. Among the same people, success in any enterprise is believed to depend greatly upon the first creature that presents itself after the enterprise is undertaken. Thus, upon going to shoot, it is reckoned lucky to meet a horse, but very unfortunate to see a hare, if she escape; and upon meeting any creature deemed unlucky, the best means of averting the omen is to roll a stone towards it. The Greeks attributed the same efficacy to the rolling of a stone, though they greatly preferred *killing* the ominous animal, that the evil portended might fall on its own head*.

The motions and appearances of the clouds were not long ago considered as certain signs by which the skilful Highlander might attain to the knowledge of futurity. On the evening before *new-year's-day*, if a black cloud appeared in any part of the horizon, it was thought to prognosticate a plague, a famine, or the death of some great man in that part of the country over which it should appear to sit; and in order to ascertain the place threatened by the omen, the motions of this cloud were often watched through the whole night, if it happened to continue so long visible above the horizon.

By the believers in this superstition there are days, as well as words and events, which are deemed ominous of good or bad fortune. The first day of every quarter, midsummer, and new-year's-day, are reckoned the most fortunate days in the year for accomplishing any design. In the Isle of Mull, ploughing, sowing, and reaping, are always begun on *Tuesday*, though the most favourable weather for these purposes be in this way frequently lost. That day of the week on which the third of May falls, is deemed unlucky throughout the whole year. In Morven, none will upon any account dig peat or turf for fuel on *Friday*; and it is reckoned unlucky to number the people or cattle belonging to any family, and doubly so if the number be taken on Friday. The age of the moon is also much attended to by the vulgar Highlanders. It is alleged, that during the increase things have a tendency to grow and stick together; and hence, in the Isle of Sky, fences, which are there made of turf, are built only at that time; whilst turf or peats for fuel are never, even in the most favourable weather, either made or stacked up but while the moon is in its wane. An opinion prevails in some places, that if a house take fire during the increase of the moon, the family to which it belongs will prosper in the world; but that if the fire happen while the moon is in the decrease, the family will from that time decline in its circumstances, and sink into poverty.

In attributing such influence to the moon, the superstitious Highlanders have the honour to agree with the philosophic Virgil, who in his *Georgics* gives the following sage instructions to the husbandman:

Omen.

* See Potter's *Antiquities*, vol. i. p. 346.

Omen.
||
St Omer's.

*Ipsa dies alios alio dedit ordine Luna
Felicis operum. Quintam fuge :*

*Septima post decimam felix et ponere vitem,
Et pressos domitare boves, et licia telæ
Addere: nona fugæ melior, contraria furtis.*

The lucky days in each revolving moon
For labour choose: the *fifth* be sure to shun.

The *seventh* is next the *tenth*, the best to join
Young oxen to the yoke, and plant the vine.
Then weavers stretch your stays upon the waft:
The *ninth* is good for travel, bad for theft.

DRYDEN.

From this coincidence of the superstition of the Roman poet with that of the natives of Mull and Morven, we are strongly inclined to adopt the hypothesis of the gentleman who favoured us with this accurate account of Highland omens. He justly observes, that this superstitious practice of auguring good or ill from trifling events, and from the particular phases of the moon, has no connection whatever with popish priestcraft: he shows that the Romish clergy, even in the darkest age, were at pains to eradicate it as idle and impious; and he therefore infers, that it must be a relick of Druidism handed down by tradition from an era prior to the introduction of Christianity into the Highlands and isles of Scotland. That the Druids were acquainted with the particular doctrines of Pythagoras has been shown elsewhere (see DRUIDS); that Virgil was no stranger to the Pythagorean philosophy is known to every scholar; that Pythagoras and his followers were addicted to the dotages of MAGIC has been made apparent in that article; and therefore it appears to us probable at least, that the attention paid to pretended omens, not only in the highlands, but also in the low country of Scotland, and indeed among the vulgar in every country of Europe, is a remnant of one of the many superstitions which the Druids imposed upon their deluded followers. That it is contrary to every principle of sound philosophy, all philosophers will readily acknowledge; and whoever has studied the writings of St Paul must be convinced that it is inconsistent with the spirit of genuine Christianity.

OMENTUM, or EPILOON, the *Cawl*, in anatomy, a membranaceous part, usually furnished with a large quantity of fat; being placed under the peritonæum, and immediately above the intestines. See ANATOMY, n° 90.

OMER, in Jewish antiquity. See CORUS.

ST OMER's, a strong, fortified, large, and populous town of France, in Artois, and capital of a considerable bailiwick, with a castle and a bishop's see. It is a fortress of considerable importance, and surrounded on one side with a large morass; and about it there are many sluices, which serve to carry the water off when it is overflowed; and in the midst of the morass there is a sort of floating islands covered with verdure and trees. The cathedral is a handsome structure; and there are other fine buildings, with a rich Benedictine abbey. The French became masters of this place in 1679. It is seated on the river Aa, and on the side of a hill, eight

miles north-west of Aire, and 135 north of Paris. E. Long. 2. 20. N. Lat. 54. 45.

Omoa.

OMOA, a Spanish town and fortification on the south side of the bay of Honduras, N. Lat. 15. 50. W. Long. 89. 50. from London. It is the key to the bay; and such is the depth of the water, that ships of any burden may ride in the harbour with safety. It is a place of the utmost importance to Spain, as the register ships to and from Guatemala are sent to it in the time of war. The town was first established in 1751, under the command of Don Joseph Antonio de Palmo. At that period the inhabitants were about 20 white men, 60 mulattoes and free negroes, and 200 slaves to the king of Spain; and the military force consisted of about 30 soldiers, besides officers. The fort was originally composed of sand confined in boarded coffers, and faced with half-burnt bricks. It was defended by 12 fine brass 24-pounders mounted, four or five iron guns of different bores, and some field-pieces. The Spaniards, sensible of the importance of the place, afterwards fortified it at an incredible expence, the stone of which the walls are built having been raised from the sea, and brought from the distance of 20 leagues. The outworks were not completely finished in the year 1779, though 1000 men had then been employed upon them for 20 years.

Towards the end of that year an expedition was undertaken against this fortress, in consequence of one formed by the Spaniards against the British log-wood cutters in the bay of Honduras and on the Mosquito shore. The latter, finding themselves hard pressed by their enemies, applied to general Dulling governor of Jamaica for assistance; who accordingly sent a detachment to their relief under Captain Dalrymple, with necessary supplies of arms, ammunition, and artillery. Before their arrival, however, the Spaniards had taken possession of St George's Key, the chief settlement of the British in these parts, which they plundered, and took a number of prisoners; but those who escaped, being joined by a body of their countrymen, retook it, and forced the enemy to retire. In the mean time Captain Dalrymple, who had been informed of the loss of the place, was hastening to the relief of the inhabitants, and in his way fell in with Admiral Parker, who was in quest of some register ships; but which, retreating into the harbour of Omoa, were too strongly protected by the fort there to be attacked by sea. As the Spaniards, however, had now been compelled to abandon St George's Key, it was proposed to unite the British forces by sea and land, and to attempt the conquest of this fortress. As the force under Captain Dalrymple was too inconsiderable to attempt the fort by land, it was augmented by the marines of the squadron and a strong party of the settlers; though, after all, it did not exceed the number of the garrison who opposed them.

The troops were landed at about nine miles distance from the fort in the dusk of the evening, with a design to march directly forward, in order to surprise and carry it by escalade in the night-time. No roads, however, being found, they were obliged to explore their way through narrow foot-paths, morasses, and over mountains so beset with precipices, that they were obliged, in order to avoid them, to make use of

Omoo.

lights made of the cabbage-tree. In consequence of these impediments they were yet at a considerable distance from the fort, when the approach of day discovered them to the enemy. An engagement ensued, in which the Spaniards were quickly routed and driven into the town; from whence as they continued to fire upon the British, it was found necessary to set fire to it, tho' very much against the inclination of the assailants.

In the mean time the squadron took the opportunity, while the town was in flames, to come into the bay, and approach the fort with an intention to batter it; but the garrison returned their fire so briskly, that no impression could be made by that of the squadron, which was detained by want of wind from approaching sufficiently near. The troops then, being masters of the ground adjacent to the fort, erected several batteries in such situations as were most proper for annoying it; but though they carried on their operations with great vigour, it was still found that heavier artillery than any they possessed would be requisite, the walls being no less than 18 feet in thickness; in consequence of which they resolved still to attempt the place by escalade.

The attempt was made on the 21st of October, early in the morning. The troops entered the ditch, which fortunately for them happened to be dry, and fixed their scaling ladders against the walls, which were near 30 feet high. Two seamen mounted first; and, with admirable courage and presence of mind, stood by the ladder which they had mounted, to guard it till others ascended; and boldly presented their pieces against a large party drawn up to receive them, though they prudently retained their fire till their comrades came up.

The squadron, now drawing near, kept up a heavy and continual fire upon the fort, while the Spaniards were struck with such surprise at the excessive celerity and boldness of the assailants, that they remained motionless and unable to oppose their enemies, notwithstanding the exhortation and example of their officers. From this panic they never recovered; and while the seamen and soldiers continued to scale the walls with amazing quickness, the Spaniards never made any effort to defend themselves. About 100 of them escaped over the walls on the opposite side of the fort; the remainder surrendered at discretion.

The whole of this transaction reflected the highest lustre both on the conduct and courage of the British; and an instance of heroism is related in a British sailor to which history affords nothing superior. This man, having scaled the walls, had armed himself with a cutlass in each hand. Thus armed, he met with a Spanish officer unarmed, and just roused from sleep. The generous tar scorned to take advantage of his condition, and therefore presented him with one of his own cutlasses, saying, "You are now on a footing with me!" The officer, however, was too much struck with admiration at his conduct to accept the offer, and took care to make the circumstance sufficiently known.—The value of the booty taken on this occasion amounted to three millions of dollars; but the loss most sensibly felt by the Spaniards was that of 250 quintals of quicksilver, a commodity indispensibly necessary in extracting the precious metals from their ores. They offered therefore to ransom it at any price; but though the

retention of it was far from affording a profit equal to that offered by the Spaniards, the British commanders absolutely refused to part with it, on account of the advantages the enemy would derive from having the metal in their possession. For the same reason they refused to accept of any ransom for the fort, though the governor offered to lay down 300,000 dollars for it. The Spanish military and the inhabitants were treated with the utmost humanity; their personal effects remaining untouched: and this generosity must have appeared to greater advantage, when contrasted with the behaviour of their own countrymen at Honduras, where the British were treated with remarkable severity. The church plate and ornaments were restored, on condition that the terms of capitulation should be faithfully kept.

In a short time, however, it appeared that it would have been better to have accepted of a ransom for the fort, as from circumstances at that time it could not be retained in the possession of Britain. A garrison was indeed left for its defence on the departure of the British squadron; but as it was very inconsiderable, on account of the small number of men that could be spared, the Spaniards quickly determined to make an attempt to regain the fort. For this purpose a body of 2000 men were collected, who invested it on the 25th of November. The British defended it with the utmost bravery; keeping up a constant fire on the enemy, and obliging them to retire for shelter, and take up their quarters behind a hill. Here they made preparations for an assault, in which their numbers left the success, as they supposed, by no means dubious. The garrison was therefore summoned to surrender, with a promise of the honours of war and a safe conveyance to Great Britain, denouncing at the same time the utmost vengeance in case of a refusal; which being refused, the necessary preparations were made for an escalade.

The condition of the garrison was now such as could afford very little hope of being able to make any effectual resistance. They were but 85 in number, most of whom were become incapable of duty either from illness or excessive fatigue. They were now also obliged to make one sentinel answer for five, by shifting his place, and challenging as many times. There was no surgeon to attend the sick and wounded; nor had they even any water but what came from a sloop of war that lay abreast of the fort. In this desperate situation, they resolved, notwithstanding the menaces of the Spanish commander, to render the place as unserviceable as they could. For this purpose they spiked up all the guns; destroying the stores and ammunition that could not be carried off: they even locked the gates of the fort, after which they embarked without the loss of a single man. All this was performed in defiance of the large force that besieged them; and the exploit, when duly considered, must appear not less a matter of astonishment than the extraordinary manner in which the fort had been taken. The officer who commanded in this remarkable retreat was Captain Hulke of the navy.

OMOPHAGIA, an ancient Greek festival, in honour of Bacchus, surnamed *Omophagos*, i. e. eater of raw-flesh. This festival was observed in the same manner with the other festivals of Bacchus, in which they

Omoo,
Omopha-
gia.

coun-

Omphacine-oil
||
Omphalea.

counterfeited madness. What was peculiar to it, was, that the worshippers used to eat the entrails of goats, raw and bloody, in imitation of the god, who was supposed to do the same thing.

OMPHACINE-OIL, a viscous brown juice extracted from green olives. With this oil the ancient *Athleta*, when going to wrestle, anointed themselves; and when that gymnastic exercise was over, they rolled themselves in the sand, which, mixing with the oil and sweat on their bodies, constituted the *strigmenta* so highly esteemed in the cure of several diseases. This precious medicine was carefully scraped off the body of the *Athlet* with a kind of instrument something like a comb, which was called *strigilis*; and such was the demand for the scrapings, that they were a very lucrative article of trade.

OMPHALE (fab. hist.), a queen of Lydia, daughter of *Jardanus*. She married *Tmolus*, who at his death left her mistress of his kingdom. *Omphale* had been informed of the great exploits of *Hercules*, and wished to see so illustrious a hero. Her wish was soon gratified. After the murder of *Eurytus*, *Hercules* fell sick, and was ordered to be sold as a slave, that he might recover his health and the right use of his senses. *Mercury* was commissioned to sell him, and *Omphale* bought him, and restored him to liberty. The hero became enamoured of his mistress, and the queen favoured his passion, and had a son by him, whom some call *Agelaus*, and others *Lamon*. From this son were descended *Gyges* and *Cræsus*; but this opinion is different from the account which makes these Lydian monarchs spring from *Alcæus*, a son of *Hercules*, by one of the female servants of *Omphale*. *Hercules* is represented by the poets as so desperately enamoured of the queen, that, to conciliate her esteem, he spins by her side among her women, while she covers herself with the lion's skin, and arms herself with the club of the hero, and often strikes him with her sandals, for the uncouth manner with which he holds the distaff, &c. Their fondness was mutual. As they once travelled together, they came to a grotto on mount *Tmolus*, where the queen dressed herself in the habit of her lover, and obliged him to appear in a female garment. After they had supped, they both retired to rest in different rooms, as a sacrifice on the morrow to *Bacchus* required. In the night *Faunus*, or rather *Pan*, who was enamoured of *Omphale*, introduced himself into the cave. He went to the bed of the queen, but the lion's skin persuaded him that it was the dress of *Hercules*; and therefore he repaired to the bed of *Hercules*, in hopes to find there the object of his affections. The female dress of *Hercules* deceived him, and he laid himself down by his side. The hero was awakened, and kicked the intruder into the middle of the cave. The noise awoke *Omphale*, and *Faunus* was discovered lying on the ground, greatly disappointed and ashamed.

OMPHALEA, in botany: A genus of the triandria order, belonging to the monoclase of plants; and in the natural method ranking with those of which the order is doubtful. The male calyx is tetraphyllous; there is no corolla; the receptacle, into which the antheræ are sunk, is ovate. The female calyx and corolla are as in the male; the stigma trifid; the capsule carnos and trilocular, with one seed.

OMPHALO-MESENTERIC, in anatomy. All festu-
tuses are wrapped up in at least two coats or mem-
branes; most of them have a third, called *allantoides*,
or urinary. Omphalo-
mesenteric
||
Onania.

Some, as the dog, cat, hare, &c. have a fourth, which has two blood-vessels, viz. a vein and an artery, called *omphalo-mesenterics*, because passing along the string to the navel, and terminating in the mesentery.

OMRAH, a man of the first rank in the Mogul empire; a nobleman. It is the plural of the Arabic *ameer*.

ON, (anc. geog.), a city of Egypt sacred to the sun, and by the Greeks, on that account, called *Helio-polis*. (See *HELIOPOLIS*.) It was remarkable for the wisdom and learning of its priesthood, and for the spacious buildings in which they cultivated the studies of philosophy and astronomy. The priests of *On* were esteemed more noble than all the other priests of Egypt. They were always privy counsellors and ministers of state; and therefore, when *Pharaoh* resolved to make *Joseph* prime minister, he very wisely gave him in marriage a daughter of the priest of *On*, thereby incorporating him into the most venerable cast in Egypt. *Bishop Warburton* thinks that the superior nobility of the priests of *On* was chiefly owing to their high antiquity and great learning. That they were much given to the study of astronomy, we know from the testimony of *Strabo*; and indeed nothing is more probable than that they should be attached to the study of that system over which their god, the SUN, presided, not only in his moral but also in his natural capacity. The learned prelate affirms, that "whether they received the doctrine from original tradition, or invented it at hazard (which last supposition he thinks more probable, though we are of a very different opinion), it is certain they taught that the Sun is in the centre of its system, and that all the other bodies move round it in perpetual revolutions. This noble theory (he continues) came with the rest of the Egyptian learning into Greece (being brought thither by *Pythagoras*, who received it from *Cenuphis**, a priest of *On*); and after having given the most distinguished lustre to his school, it sunk into obscurity, and suffered a total eclipse throughout a long succession of learned and unlearned ages; till these times returned its ancient splendor, and immoveably fixed it on the unerring principles of science."

If it be true, as some philosophers allege, that *Moses* appears from the first chapter of *Genesis* to have been acquainted with the true solar system, this account of the origin of that system is extremely probable. As it is of no importance to the civil or religious constitution of a state whether the system of *Ptolemy* or that of *Copernicus* be admitted by the people, we cannot reasonably suppose that the Jewish lawgiver was taught astronomy by a revelation from Heaven. But there can be no doubt of his knowing as much of that science as the priests of *On*; for we know that he was instructed in all the wisdom of the Egyptians; and therefore, if he held the sun to be in the centre of the system, it is morally certain that the same thing was held by that priesthood.

ONANIA, or ONANISM, terms lately framed to denote the crime of self-pollution, mentioned in scripture.

* *Plut. de Is. et Osir.*
p. 632.
Steph. ed.

Onania. ture to have been committed by Onan, and punished in him with death.

This practice, however common, hath among all nations been reckoned a very great crime. In scripture, besides the instance of Onan above-mentioned, we find self-polluters termed *effeminate, unclean, filthy, and abominable*. Even the heathens, who had not the advantage of revelation, were of the same opinion, as appears from the following lines of Martial.

*Hoc nihil esse putes! scelus est, mihi crede; sed ingens
Quantum vix animo concipis ipse tuo.*

You think 'tis nothing! 'tis a crime, believe!
A crime so great you scarcely can conceive.

Dr Tissot has published a treatise on the pernicious effects of this shameful practice, which appears to be no less baneful to the mind than to the body. He begins with observing, that, by the continual waste of the human body, aliments are required for our support. These aliments, however, require certain preparations in the body itself; and when by any means we become so altered that these preparations cannot be effected, the best aliments then prove insufficient for the support of the body. Of all the causes by which this morbid alteration is brought on, none is more common than too copious evacuations; and of all evacuations, that of the semen is the most pernicious when carried to excess. It is also to be observed, that though excess in natural venery is productive of very dangerous disorders, yet an equal evacuation by self-pollution, which is an unnatural way, is productive of others still more to be dreaded. The consequences enumerated by Dr Tissot are as follow:

1. All the intellectual faculties are weakened; the memory fails; the ideas are confused, and the patient sometimes even falls into a slight degree of insanity. They are continually under a kind of inward restlessness, and feel a constant anguish. They are subject to giddiness; all the senses, especially those of seeing and hearing, grow weaker and weaker, and they are subject to frightful dreams.

2. The strength entirely fails, and the growth in young persons is considerably checked. Some are afflicted with almost continual watching, and others dose almost perpetually. Almost all of them become hypochondriac or hysteric, and are afflicted with all the evils which attend these disorders. Some have been known to spit calcareous matter; and others are afflicted with coughs, slow fevers, and consumptions.

3. The patients are affected with the most acute pains in different parts of the body, as the head, breast, stomach, and intestines; while some complain of an obtuse sensation of pain all over the body on the slightest impression.

4. There are not only to be seen pimples on the face, which are one of the most common symptoms; but even blotches, or suppurative pustules, appear on the face, nose, breast, and thighs; and sometimes fleshy excrescences arise on the forehead.

5. The organs of generation are also affected; and the semen is evacuated on the slightest irritation, even that of going to stool. Numbers are afflicted with an habitual gonorrhœa, which entirely destroys the vigour

of the constitution, and the matter of it resembles a fetid sanies. Others are affected with painful priapisms, dysuries, stranguries, and heat of urine, with painful tumours in the testicles, penis, bladder, and spermatic cord; and impotence in a greater or less degree is the never-failing consequence of this detestable vice.

6. The functions of the intestines are sometimes totally destroyed; and some patients complain of costiveness, others of diarrhœa, piles, and the running of a fetid matter from the fundament.

With regard to the cure, the first step is to leave off those practices which have occasioned the disease; which our author asserts is no easy matter; as, according to him, the soul itself becomes polluted, and can dwell on no other idea; or if she does, the irritability of the parts of generation themselves quickly recal ideas of the same kind. This irritability is no doubt much more to be dreaded than any pollution the soul can have received; and by removing it, there will be no occasion for exhortations to discontinue the practice. The principal means for diminishing this irritability are, in the first place, to avoid all stimulating, acrid, and spiced meats. A low diet, however, is improper, because it would further reduce the body, already too much emaciated. The food should therefore be nutritive, but plain, and should consist of flesh rather roasted than boiled, rich broths, &c. It is certain, however, that as these foods contribute to restore the strength of the body, the stimulus on the organs of generation will be proportionably increased by the semen which is constantly secreted, and which will now be in larger quantity than even in healthy persons, owing to the great evacuations of it which have preceded. Some part of the semen is gradually absorbed by the lymphatics; in consequence of which, the remainder becomes thick, acrid, and very stimulating. To remedy this, exercise is to be used, and that not only for pleasure, but till it is attended with a very considerable degree of fatigue. The sleep also must be no more than is barely sufficient to repair the fatigues occasioned by the exercise, or other employment; for an excess in sleep is as bad as idleness or stimulating foods. Excess in wine or intoxicating liquors is also to be avoided; or rather such liquors ought never to be tasted, unless as a medicine to restore the exhausted spirits; and to all this ought to be joined the Peruvian bark, which hath this admirable property, that, with little or no stimulus, it restores the tone of the system, and invigorates the body in a manner incredible to those who have not observed its effects. If these directions are followed, the patient may almost certainly expect a recovery, provided any degree of vital strength remains; and those who desire a life of celibacy on a moral account, will find them much more effectual than all the vows of chastity they can make.

ONCA and ONCE. See FELIS, vi. and iv.

ONEEHOURA and ONEEHOW, two small islands of that cluster which was discovered by Captain Cook, and by him called the *Sandwich Islands*. (See SANDWICH ISLANDS). *Oneehoura* is very small, and its chief produce is yams. *Oneehow* is considerably larger, being about ten miles over. It is remarkable for the great quantity of excellent yams which it produces, and for a sweet root called *tee* or *tea*, which is generally

Onania
||
Oneehoura
and *Once-*
how.

Plate CCCXLIX.

Orchis mascula.



Olea fragrans.



Onisci.



A. Bell Pin. Nat. Sculptor fecit.

Onega
||
Oneirocritics.

ly about the thickness of a man's wrist, though sometimes much larger. This root, which the natives commonly bake previous to their bringing it to market, is of a wet clammy nature, and with proper management makes excellent beer.

ONEGA, a river and lake of the Russian empire, between Muscovite Carelia, the territory of Cargapol, and Swedish Carelia. It is 100 miles in length and 40 in breadth, having a communication with the lake Ladoga, and consequently with Petersburg. The river has its source in Cargapol, and gives its name to a country full of woods.

ONEGLIA, a sea-port town of Italy, in the territory of Genoa, with the title of a principality; but it belongs to the king of Sardinia, as well as the province, which abounds in olive-trees, fruit, and wine. It has often been taken and retaken in the wars of Italy; which is no wonder, as it is an open place. The French and Spaniards had possession of it in 1744, but were driven out by the Piedmontese; however, they returned next winter, and again made themselves masters of it. E. Long. 7. 51. N. Lat. 43. 58.

ONEIROCRITICA, the art of interpreting dreams; or a method of foretelling future events by means of dreams. See DREAM, DIVINATION, &c.—The word is formed from the Greek *oneiro*, “dream,” and *critica*, of *κρισις*, “judgment.”—Some call it *oneirocratica*; and derive it from *ονειρος* and *κρατω*, “I possess, I command.”

It appears from several passages of scripture, that there was, under the Jewish dispensation, such a thing as foretelling future events by dreams; but then there was a particular gift or revelation required for that purpose.

Hence it has been inferred, that dreams are really significative, and do forbode something to come; and all that is wanting among us is the *oneirocritica*, or the art of knowing what: yet it is the opinion of many, that dreams are mere chimeras; bearing indeed some relation to what has passed, but none to what is to come.—As to the case of Joseph, it was possible for God, who knew all things, to discover to him what was in the womb of fate; and to introduce that, he might take the occasion of a dream.

ONEIROCRITICS, a title given to interpreters of dreams, or those who judge of events from the circumstances of dreams.

There is no great regard to be had to those Greek books called *oneirocritics*; nor do we know why the patriarch of Constantinople, and others, should amuse themselves with writing on so pitiful a subject.

Rigault has given us a collection of the Greek and Latin works of this kind; one attributed to Astrampichus; another to Nicephorus, patriarch of Constantinople; to which are added the treatises of Artemidorus and Achmet. — But the books themselves are little else than reveries; a kind of waking dreams, to explain and account for sleeping ones.

The secret of oneirocriticism, according to them all, consists in the relation supposed to be between the dream and the thing signified: but they are far from keeping to the relations of agreement and similitude; and frequently have recourse to others of dissimilitude and contrariety. Concerning oneirocritics and oneirocritica, the unlearned reader will find much informa-

tion in Warburton's Divine Legation of Moses, and the books to which he refers.

ONESIÆ THERMÆ, were, according to Strabo, excellent baths, and salutary waters, at the foot of the Pyrenees in Aquitania. Near the river Aturus stands at this day the town Bagnères, famous for its waters, which appear to be the *Onesiæ* of Strabo; situated in the county of Bigorre in Gascony, near the river Adour.

ONIÆ OPPIDUM and *Templum*, (Josephus); so called from Onias, the high-priest of the Jews in Egypt; who built a temple in imitation of that at Jerusalem, by permission of the king of Egypt, on the spot where stood the temple of Diana Agrestis in Leontopolis: it was encompassed with a brick-wall, and had a large tower like that at Jerusalem, (Josephus:) it was the metropolis of the Nomos Heliopolites, (Ptolemy;) because in Strabo's time Heliopolis was fallen to decay.

ONGLEE, in heraldry, an appellation given to the talons or claws of beasts or birds, when borne of a different colour from that of the body of the animal.

ONION. See ALLIUM, sp. 5.—Onions, leeks, and garlic are all of the same genus; and in their recent state are acrid, but harmless to the human body. When, by age or climate, this acrimony is too great, we do not use them as food. In Spain, the garlic being equally mild with the onion is used as common food. By the ordinary culinary preparation their acrimony is dissipated, and a remarkably mild substance remains, promising much nutriment, which those who can digest them raw will certainly obtain. Though sometimes shunned as food, yet they are on that account used in medicine, uniting the two qualities of pectorals, viz. on the account of their acrimony, being in their recent state expectorant; in their boiled state, on account of their mucilage, demulcent, provided the quantity taken be sufficient. Some of late, in this country, have found in leeks a somniferous quality; but this is not yet confirmed by a sufficient number of experiments.—Besides the three above-mentioned, there are several others belonging to the same tribe, which we use as condiment; but only the leek and onion as diet. In its recent state, the onion is the most acrid; in its boiled state, the leek retains its acrimony most tenaciously. On account of this, and some difference of texture, the onion is more easily digested and more universally used than the leek; being more easily broke down, and more generally agreeable.

ONISCUS, in zoology, a genus of insects belonging to the order of aptera. It has 14 legs, bristly feelers, and an oval body. There are 15 species; of which the most remarkable are,

1. The *entomon*, or *sea wood-louse*, is white; eyes black; convex above, beneath flat, margin acute; Antennæ 4: Four hind pair of legs largest, hairy. Body of 10 segments. Length $1\frac{1}{2}$ line. Found on the coast. It accompanies the herring, and is an enemy well known to our fishermen; these insects will frequently eat up a whole fish while it hangs in the net.

2. *Oniscus aquaticus*, is of an ashen-colour, and tolerably smooth. Its body is composed of seven articulations, exclusive of the head and tail; which last part

Onesiæ
thermæ
||
Oniciæ.

Plate
CCCXLIX

Oniscus
Onkelos.

is much larger than the other segments, round at the extremity, and from which issue two appendices, each divided into two threads. This insect has that in common with some sea-onisci, but differs from them by the sea ones having ten segments. This has seven legs on each side; the last of which gradually increase in length, and are constantly larger than the foremost. The antennæ have but three long articulations, the last of which is much longer than the rest. This insect is found in pools, small rivulets, and especially in springs.

3. *Asellus, millepes*, or *wood-louse*, is oval; the tail obtuse, with two undivided bristles: various as to colour: length, 5 lines. Their use in medicine is well known.

4. *Oniscus armadillo* is broad, very glossy, and smooth: its colour is black, with a small portion of white on the edge of the segment, which colour often varies; but still the insect is glossy and smooth. Its body is composed of ten segments, besides the head and tail. Of the ten segments, the first seven are broad, and the last three short. The first of these three appears divided in the middle, which is broader than the rest, into three more. These last short segments, with that of the tail, form the extremity of the animal's body, which is round, without any appendix, and constitutes the specific character of this insect. It has fourteen feet, seven on each side. This oniscus, when touched, rolls itself up into a ball, bringing its head and tail together like the animal called *armadillo*, and neither antennæ nor feet are seen: it might be taken for a round, shining pearl. This oniscus is found in woods.

ONKELOS, surnamed the *Profelyte*, a famous rabbi of the first century, and the author of the Chaldee Targum on the Pentateuch. He flourished in the time of Jesus Christ, according to the Jewish writers; who all agree that he was, at least in some part of his life, contemporary with Jonathan Ben Uzziel, author of the second Targum upon the prophets. Dean Prideaux thinks he was the elder of the two, for several reasons: the chief of which is the purity of the style in his Targum, therein coming nearest to that part of Daniel and Ezra which is in Chaldee, and is the truest standard of that language, and consequently is the most ancient; since that language, as well as others, was in a constant flux, and continued deviating in every age from the original: nor does there seem to be any reason why Jonathan Ben Uzziel, when he understood his Targum, should pass over the law, and begin with the prophets, but that he found Onkelos had done this work before him, and with a success which he could not exceed.

Azarías, the author of a book intitled *Meor Enaim*, or the *light of the eyes*, tells us, that Onkelos was a profelyte in the time of Hillel and Samnai, and lived to see Jonathan Ben Uzziel one of the prime scholars of Hillel. These three doctors flourished 12 years before Christ, according to the chronology of Gauz; who adds, that Onkelos was contemporary with Gamaliel the elder, St Paul's master, who was the grandson of Hillel, who lived 28 years after Christ, and did not die till 18 years before the destruction of Jerusalem. However, the same Gauz, by his calculation, places

Nº 246.

5

Onkelos 100 years after Christ; and to adjust his opinion with that of Azarías, extends the life of Onkelos to a great length. The Talmudists tell us that he assisted at the funeral of Gamaliel, and was at a prodigious expence to make it most magnificent. Dean Prideaux observes, that the Targum of Onkelos is rather a version than a paraphrase; since it renders the Hebrew text word for word, and for the most part accurately and exactly, and is by much the best of all this sort: and therefore it has always been held in esteem among the Jews, much above all the other Targums; and being set to the same musical notes with the Hebrew text, it is thereby made capable of being read in the same tone with it in their public assemblies. From the excellency and accuracy of Onkelos's Targum, the dean also concludes him to have been a native Jew, since, without being bred up from his birth in the Jewish religion and learning, and long exercised in all the rites and doctrines thereof, and being also thoroughly skilled in both the Hebrew and Chaldee languages, as far as a native Jew could be, he can scarce be thought thoroughly adequate to that work which he performed; and that the representing him as a profelyte seems to have proceeded from the error of taking him to have been the same with Akilas, or Aquila, of Pontus, author of the Greek Targum or version of the prophets and Hagiographia, who was indeed a Jewish profelyte.

ONKOTOMY, in surgery, the opening of a tumour or abscess. See SURGERY.

ONOCLEA, in botany: A genus of the natural order of filices, belonging to the cryptogamia class of plants. The spike is flat, and turned to each side, with quinquevalved fructifications.

ONOMANCIA, or rather ONOMANTIA, a branch of divination, which foretels the good or bad fortune of a man, from the letters in his name. See the article DIVINATION, and NAME.

From much the same principle the young Romans toasted their mistresses as often as there were letters in their names: Hence Martial says,

Nævia sex cyathis, septem Justina bibatur.

ONOMATOPOEIA, in grammar and rhetoric, a figure where words are formed to resemble the sound made by the things signified; as the buzz of bees, the cackling of hens, &c. Resemblances of this kind are often fancied when they are not real, though, no doubt, there are in every language some words of which the sound is very like to that which those words are employed to express. Yet, to the mortification of grammarians and rhetoricians, conjunctions, which have been justly pronounced no parts of speech, are the only sounds uttered by men that are wholly natural, and these are fewer than is commonly supposed. See GRAMMAR and LANGUAGE.

ONONIS, in botany: A genus of the decandria order, belonging to the diadelphia class of plants. The calyx is quinquepartite, with the segments linear; the vexillum striated; the legumen turgid and sessile; the filaments coalited without a fissure.

ONOPORDUM, in botany: A genus of the polygamia æqualis order, belonging to the syngenesia class of plants; and in the natural method ranking under the

Onkotomy
Onopordum.

Onosander the 49th order, *Compositæ*. The receptacle is honey-combed; the scales of the calyx mucronated or pointed.

ONOSANDER, a Greek author and Platonic philosopher, who wrote Commentaries on Plato's politics, which are lost: but his name is particularly famous for a treatise intitled *Λόγος Στρατηγικός*, "Of the duty and virtues of the general of an army;" which has been translated into Latin, Italian, Spanish, and French. The time when he lived is not precisely known: but is imagined to be in the reign of the emperor Claudius.

ONOSMA, in botany: A genus of the monogynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 41st order, *Asperifoliæ*. The corolla is campanulated, with the throat pervious: there are four seeds.

ONTARIO, a lake of North America, in the country of the Iroquois, 180 miles in length and 60 in breadth. There are many rivers that run into it; and from it the great river St. Laurence proceeds. It communicates with lake Erie by a river 33 miles in length, in which is the remarkable cataract of NIAGARA.

ONTOLOGY. See METAPHYSICS, n^o 3.

ONUPHRIUS PANVINUS, a learned Italian, of the order of hermits of St. Augustine, was born of a noble family at Verona, in 1529; and, being trained to literature, became so indefatigable in his studies, that he spent whole days and nights in reading the ancients: which made Manutius style him *Helluo Antiquitatis*. His first performance was A Chronicle of Popes and Cardinals, which was printed without his knowledge at Venice in 1557; and some time after, more correctly by himself. He afterwards continued Platina's Lives of the Popes, from Sextus IV. to Pius V. and subjoined annotations to the lives Platina had written. He also wrote four pieces upon Roman Antiquities, which are printed in Grævius's Collection. He died in his 39th year, in 1568.

ONYCOMANCY, or, as some write it, **ONYMANCY**; a kind of divination by means of the nails of the fingers.—The word is formed from the Greek *ονυξ*, "nail," and *μαντια*, "divination."

The ancient practice was to rub the nails of a youth with oil and foot, or wax; and to hold up the nails thus smeared against the sun.—Upon them were supposed to appear figures or characters, which showed the thing required.

ONYX, in natural history, one of the semipellucid gems, with variously coloured zones, but none red; being composed of crystal, debased by a small admixture of earth; and made up either of a number of flat plates, or of a series of coats surrounding a central nucleus, and separated from each other by veins of a different colour, resembling zones or belts.

We have four species of this gem. 1. A bluish-white one, with broad white zones. 2. A very pure onyx, with snow-white veins. 3. The jasponyx, or horny-onyx, with green zones. 4. The brown onyx, with bluish white zones.

The ancients attributed wonderful properties to the onyx, and imagined that if worn on the finger it acted as a cardiac; they have also recommended it as an astringent; but at present no regard is paid to it.

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The word in the Greek language signifies *nail*; the poets making this stone to have been formed by the Paræ from a piece of Venus's nails, cut off by Cupid with one of his arrows.

OONALASHKA, one of the islands of the Northern Archipelago, visited by Captain Cook in his last voyage. The native inhabitants of this island are, to all appearances, a very peaceable people, having been much polished by the Russians, who now keep them in a state of subjection. As the island furnishes them with subsistence, so it does, in some measure, with clothing, which is chiefly composed of skins. The upper garment, which is made like a waggoner's frock, reaches down to the knees. Besides this, they wear a waistcoat or two, a pair of breeches, a fur cap, and a pair of boots, the legs of which are formed of some kind of strong gut; but the soles and upper-leathers are of Russia leather. Fish and other sea animals, birds, roots, berries, and even sea-weed, compose their food. They dry quantities of fish during the summer, which they lay up in small huts for their use in winter. They did not appear to be very desirous of iron, nor to want any other instrument, except sewing needles, their own being formed of bone. With these they sew their canoes, and make their clothes, and also work very curious embroidery. They use, instead of thread, the fibres of plants, which they split to the thickness required. All sewing is performed by the females, who are shoe-makers, tailors, and boat-builders. They manufacture mats and baskets of grass, which are both strong and beautiful. There is indeed a neatness and perfection in most of their works, that shows they are deficient neither in ingenuity nor perseverance.

Though the climate is sometimes severe, Captain Cook did not observe a fire-place in any of their habitations. They are lighted as well as heated by lamps; which, though simple, effectually answer the purpose for which they are intended. They consist of a flat stone, hollowed on one side like a plate; in the hollow part they put the oil, mixed with some dry grass, which serves for a wick. Both sexes often warm themselves over one of these lamps, by placing it between their legs, under their garments, and sitting thus over it for several minutes. E. Long. 139. 29. N. Lat. 53. 5.

OONELLA, **OONEMAH**, two islands of the same Archipelago with Oonalashka; the former of which lies to the north-east of that island, being separated from it by a navigable strait; the other is more to the westward, being in E. Long. 192. 30. and N. Lat. 54. 30. The circumference of Oonella is about seven leagues, and the produce of both much the same with that of Oonalashka.

OORT (Adam Van), born at Antwerp in 1557, was the son of Lambert Van Oort, a painter of considerable reputation for perspective and architecture. Adam was instructed in the art by his father, and afforded sufficient proofs of his having an enlarged genius; so that he soon rose into esteem, not only as a painter of history, but as an able artist in landscape and portrait. But the greatest honour of Van Oort proceeded from his having been the first instructor of Rubens, whose works have eternized his master's memory, along with his own.

E e

Naturally

Oost.

Naturally he was of a rough and disagreeable temper, which occasioned him to lose the love of his disciples and his friends; and among the number, he totally forfeited the esteem of Rubens, his best pupil. Jordaens was the only person who accommodated himself to the savage humour of his master; but it appears probable, that he only condescended to endure his morose behaviour, out of affection to the daughter of Van Oort, to whom Jordaens was afterwards married.

In his style of painting, however, he neglected nature, and was entirely a mannerist; nor did he seem to have any regard to painting as a fine art, but merely as an art that might be the means of making him rich. In his best time, his composition was agreeable and his design correct; but in his latter time, his works had nothing to recommend them, except the freedom of handling, and the goodness of their colouring; yet, with all his defects, he was accounted a good painter. Rubens used to say, that Van Oort would have surpassed all his contemporaries, if he had seen Rome, and formed his taste by studying after the best models. He painted a great number of designs for the altars of churches in Flanders, which have much merit in several parts; and they are still beheld with pleasure by good judges.

OOST, a kiln for drying hops after they are picked from the stalks.

Oost (Jacques Van), a painter of history, landscape, and architecture, was born at Bruges about the year 1600, and learned the art in his native city, though it is not ascertained by what master he was instructed; but he travelled to Italy, to study after the works of the great masters, and copied every thing that pleased his own taste, or that he thought might contribute to his improvement. However, among all the famous artists, he attached himself particularly to the style of Annibal Caracci, and imitated him in such a manner, as to surprise the most able connoisseurs at Rome.

He possessed many of the accomplishments of a great painter. His touch and his colouring were good; he introduced but few figures in his designs, to avoid incumbering his subject; and he disposed them with a great deal of skill and elegance; giving them such draperies as were simple and natural. He designed in a good taste; and though his style of composition resembled that of Annibal, yet it was less charged than the designs of that master usually are. In his carnations, his colouring was fresh and like nature; but he is not so commendable in the colour of his draperies, which is sometimes so broken as to give the stuffs an appearance of hardness. He understood perspective and architecture extremely well; and as he was not fond of painting landscape (though occasionally he painted it well), in the stead of it he ornamented his back grounds most frequently with buildings, columns, arches, and different pieces of architecture, which gave his composition a grand effect.

The most admired picture of Van Oost is in the

church at Bruges which belonged to the Jesuits: the subject of it is, a Descent from the Cross; in which the design, the disposition, the expression, colour, and chiaro-scuro, are worthy of the highest praises. He had a son of the same name, who acquired considerable fame in his profession.

OPACITY, in philosophy, a quality of bodies which renders them impervious to the rays of light.

OPAH, commonly called the *king fish*. See ZEUS. The body is deep; the scales exceedingly minute: it has setaceous teeth on the tongue only, one long dorsal fin, and a tail somewhat lunated. The genus of which this is a species is not numerous: This, however, is considerably the largest, and with respect to its colours the most splendid. It is considered by many as the most beautiful fish that is found on the coast of Europe. Mr Pennant in his British Zoology gives the following account of this fish, which is exceedingly rare on the British coast: "We have only four instances (says he) of this fish being taken in our seas, each of them in the north, viz. twice off Scotland, once off Northumberland, and once in Filey-Bay, Yorkshire. This last was caught about two years ago, and exhibited as a show at Scarborough.

"It is of that genus which Linnæus distinguishes by the name of *Chatodon* from its bristly teeth, and is said to be very common on the coast of Guinea. (See CHÆTODON). (A)

"It is well described by an anonymous writer in the London Magazine for October 1767, which we shall borrow, as the account is confirmed to us by Mr Travis, who had an opportunity of examining one of the same species.

"Newcastle, September 12. On Saturday last was thrown upon the sands at Blyth, a very rare and beautiful fish, weighing between 70 and 80 pounds, shaped like the sea-bream. The length was three feet and an half; the breadth from back to belly almost two feet; but the thickness from side to side not above six inches.

"The mouth small for the size of the fish, forming a square opening, and without any teeth in the jaws. The tongue thick, resembling that of a man, but rough and thick set with beards or prickles, pointing backwards, so that any thing might easily pass down, but could not easily return back; therefore these might serve instead of teeth to retain its prey. The eyes remarkably large, covered with a membrane, and shining with a glare of gold. The cover of the gills like the salmon.

"The body diminishes very small to the tail, which is forked, and expands 12 inches: the gill fins are broad, about eight inches long, and play horizontally: a little behind their insertion the back fin takes its original, where it is about seven inches high, but slopes away very suddenly, running down very near the tail, and at its termination becomes a little broader: the belly fins are very strong, and placed near the middle of the body: a narrow fin also runs from the anus to the tail.

(A) Later writers seem with more propriety to have ranked it under the genus *Zeus*, to which we have already referred.

Opal.

"All the fins, and also the tail, are of a fine scarlet; but the colours and beauty of the rest of the body, which is smooth and covered with almost imperceptible scales, beggars all description; the upper part being a kind of bright green, variegated with whitish spots, and enriched with a shining golden hue, much resembling the splendour of the peacock's feathers; this by degrees vanishes in a bright silver; and near the belly the gold begins again to predominate in a lighter ground than on the back."

OPAL, in natural history, a species of the chroa-faces genus of gems.—This species of precious stone is generally esteemed the most beautiful of all the flinty tribe, which appears to be owing to its changeable appearance when viewed by reflection.—The form of the opal is that of a pebble, like the agate, with which authors in general have classed it, from a supposed resemblance, of which there appears no sort of proof. On the contrary, Bergman's analysis points it out to be of a very different nature from the genus of flints, of which the agate is a species; magnesia constituting a large part of its composition, and not entering at all into that of the agate, if we are to judge from the analysis of the parent species or flint, there being none yet published of agate. The specific gravity of the opal is likewise extremely different from that of the agate. Wallerius tells us that its specific gravity is upwards of 1900. It loses its colour and transparency in the fire, and in other respects is affected by it in the very same manner as quartz or flint would be. It may be melted with borax, but not without great difficulty. The species are,

1. The opal of Nonnius. This appears olive-coloured by reflection, and then opaque; but when held between the eye and the light, it is found to be transparent, and appears of a beautiful ruby colour. Bocce de Boot, author of the *Complete Jeweller*, considers it as the most precious sort of opal, and indeed the most wonderful of this kind of nature's works: he gives a lofty encomium upon it, chiefly from Pliny, who called this opal *paderos*. This species of opal is the *sangenon* of India, and *nonnius* of the ancients and modern Europeans, from the Roman senator Nonnius, possessor of the famous opal of Rome, worth 20,000 sesterces, who preferred banishment to parting with it to Anthony. An opal answering exactly to Pliny's description of the nonnius was discovered about 30 or 35 years ago in the ruins of Alexandria, and purchased for a trifle by the French consul Lironcourt, from his draguman Roboly. The duke de Nivernois, when ambassador in London in 1763, was in possession of the very stone. The next in esteem and value is the Iris opal, of a glassy white colour, but when looked through it appears of a flame-colour, as the nonnius does of a ruby.

Wallerius indeed is of opinion that the opal found in Alexandria was not that of Nonnius mentioned by Pliny; and adds, that it was by many supposed to be only a counterfeit piece of glass or paste. There is another of the same species in Sweden, which by reflection appears of a brownish colour, but by refraction is red with violet veins.

2. The white opal, having its ground of a white glass-like complexion, from whence green, yellow,

Opal. bluish, and purple rays are thrown out; but when held against the light it appears of a reddish or rather flame-colour. Wallerius, in his *Mineralogy*, says, that this white opal answers the description of it given by Pliny much better than the olive-coloured one above described. There are two varieties of it: 1. The oriental opal, showing many colours.—Engenstroom informs us, that he had obtained a small piece of pseudo agate from the East Indies, of a yellowish brown and pale blue, or rather milk-colour, with a shining brightness, exactly like that of the milky opals already mentioned; also some other specimens near Turin in Piedmont, where they are called *bassard-agates*, a name which, in his opinion, is extremely proper for them, as they agree with the agates in almost every respect except hardness: this, however, has been controverted.—Sometimes the opal is surrounded with a white crust, like common flints in the strata of chalk; which crust has likewise the same properties as the flint when this last mentioned substance has been previously freed from the adherent chalk; viz. 1. It does not dissolve in nitrous acid. 2. It is not fusible *per se*. 3. It melts pretty easily with borax, but without any effervescence, contrary to what is observed in calcareous substances; so that borax will dissolve about three quarters of its own bulk of this substance, though with difficulty, especially towards the end of the operation; but the glass becomes quite clear and colourless, instead of becoming white and opaque, as is the case with calcareous substances. This oriental stone is found in the island of Ceylon, where it is called the *elementary stone*. The Indians put as high a value on it as on the diamond. There is another kind of oriental opal much valued, generally called the *flaming opal*, because it changes its colours, as if sparks of fire escaped from it in parallel lines.

3. The bluish and semitransparent opal is less valued by those who are conversant in gems than the others, on account of its being supposed more easily imitable by art. M. Magellan, however, informs us, that not only this, but several other kinds of opals are easily imitable by art; several compositions of glass being met with which show very different colours by reflection and by refraction. A curious ancient one of this kind is to be seen in the royal abbey of St Denis near Paris, which is green on the outside, but shows a fine ruby-colour when held between the eye and the light. Our author has also seen some glass pastes made in London by Edward Delaval, Esq; and others by Mr More secretary to the Society of Arts, which appeared of a yellow-brown or other colour by reflection; but when held against the light transmitted a fine blue, purple, or red colour, like the sapphires, rubies, garnets, and other precious stones.—Wallerius gives directions for making these pastes; and M. Magellan informs us, that he by chance discovered that the red glass of Kunckel, when over-melted, or burnt in a common fire, produces a similar effect, transmitting one colour by refraction and another by reflection. The fine imitations of the true white opals, which Pliny says were made by the Indians, have, in our author's opinion, hitherto baffled the art of the moderns.

Opal,
Opalia.

The sanganon, or nonnius opal is found in the East Indies; the Iris, in Ceylon; the milky opal, at Eilbenstock and Fryberg; the bluish or most common and least esteemed, in Hungary, Silesia, Saxony, &c.; the olive and bottle coloured cat's eye, in Ceylon; the inferior in different countries of Europe. Mr Born mentions what he calls an *avanturine cat's eye*, of a flesh colour and transparent, possessing the curious structure of the *avanturine*, viz. composed of little plates like scales, with a metallic splendour, which reflect the rays of light like the opal. This stone we suspect to be that which has led authors to class the *avanturine* with the opal, although it is in fact a fine opaque quartz. Russia produces the opal at the rivulet Katscha, near the city of Krasnajak, in the Altai mountains in Siberia. The cat's eye is found in Mount Caucasus, and is often confounded with the opal, though improperly. See ASTERIA. The *oculus mundi* (see HYDROPHANES) has a very intimate connection with opal, being generally found in beds over it, and being regarded by some naturalists as the same stone in a state of decomposition by the action of the air. Russia possesses this stone in the Altai mountains, where the opals are found.

No method of estimating the opal is given by authors that we know of. But those of uncommon beauty and size are sold for very large sums.

The late Leopold II. emperor of Germany, was in possession of an oriental stone, sometimes described as a cat's-eye and sometimes as an opal, of one inch diameter, and which was valued at a great price. Prince Potemkin, the Russian general, purchased for 1000 ducats a stone of the same kind, said to have been taken by the famous Nadir Shah from the head of a Gentoo idol, of which it made one of the eyes. By what circuitous road it found its way to Potemkin, we have not been informed; but with many other gems it disappeared from the tent of the Persian conqueror when he was assassinated.

Opals are commonly found in detached pieces, in an envelope of a different kind of stone, from the size of a pin-head to that of a walnut. Beautiful opals of this last size are extremely rare; so that it is difficult to find an opal sufficiently perfect and large to be completely possessed of all its beauties: this renders it so precious, and makes it almost impossible to determine its value. They have agreed, however, to value a beautiful oriental opal at double the price of a sapphire of the same size.

It is very remarkable, that all the beautiful colours of the opal may entirely change or disappear when the stone is divided into pieces. This phenomenon, which has been demonstrated more than once by experience, leads us to think that all the sparkling play of the opal is owing to the refraction of the rays of the sun from the surface of the stone, which is naturally formed to produce this refraction.

OPALIA, in antiquity, feasts celebrated at Rome in honour of the goddess Ops. Varro says they were held on the 19th of December, which was one of the days of the *saturnalia*: these two feasts were celebrated in the same month, because Saturn and Ops were husband and wife: the vows offered to the goddess were made sitting on the ground.

OPERA, a dramatic composition set to music, and sung on the stage, accompanied with musical instruments, and enriched with magnificent dresses, machines, and other decorations.—This species of drama is of modern invention. In its present state it was not known even in Italy before the beginning of the last century; and at its introduction into England, a century afterwards, it divided the wits, literati, and musicians of the age. By those who were esteemed the best judges of the art, the English language was considered as too rough and inharmonious for the music of the opera; and, on the other hand, critics, whose taste was built on the basis of common sense, looked upon a drama in a foreign and unknown tongue as the greatest of all absurdities. Many of them, however, pleaded for operas in the English language; and it is well known that Addison, who was one of the opposers of the Italian opera on the London stage, wrote in his native tongue the opera of Rosamond. This is confessedly a beautiful poem; but, in the opinion of Dr Burney, it adds nothing to Addison's fame, as it shows his total ignorance of the first principles of music, and of course his unsuitness for the task he had undertaken.

In questions respecting the fine arts there is no appeal from the general taste; and therefore, as the French opera, which is in the language of the country where it is acted, has always been admired by persons of liberal education, it doubtless has merit considered as a drama; but how the dramas of this kind which are composed in Italian should find admirers in England, among persons who understand not a word of the language, is to us a matter of astonishment. The music of them may deserve and command the admiration of every one who has an ear; and the action of the fingers may be perfectly suitable to the subject represented; but of this suitability the majority of the audience can be no judges.

Even when the language is thoroughly understood, we should imagine, that, to make an opera agreeable to good sense, much would depend upon the choice of the subject; for it is surely absurd to have persons of all ranks, and on every occasion, perpetually accompanied with the regular responses of symphony. To hear Cæsar, Scipio, or Macbeth, when forming plans to ensure victory, or hatching plots of treason and murder, talking in recitative and keeping time with fiddles, would surely disgust every person whose sense had not all evaporated in sound; but when the subject represented naturally admits of music in real life, we can suppose an opera to afford to persons of taste one of the most exquisite and refined entertainments of which human nature is capable. For a further account of the opera, see Music, n° 39, 42, 44, and POETRY, n° 133, &c.

OPERATION, in general, the act of exerting or exercising some power or faculty, upon which an effect follows.

OPERATION, in surgery and medicine, denotes a methodical action of the hand on the human body, in order to re-establish health.

OPHIDIUM, a genus of fishes belonging to the order of apodes. The principal characters of this genus are the following. The head is somewhat naked; the

Opera
||
Ophidium.Plate
CCCLL

Ophidium. the teeth are in the jaws, palate, and fauces; the body long; the fins of the back, tail, and anus, confounded in one; no fin on the under part of the body; and the eyes covered by the common skin. Of this genus there are several species, of which the most curious is the *ophidium barbatum* of Linnæus, thus described by Dr Broussonet in the 71st volume of the Philosophical Transactions.

"The scales of the ophidium (says he) are irregularly placed and dispersed over the whole body. Their form is sometimes round, sometimes nearly oval. They are larger near the head, and in the lower part of the body; but are hardly to be distinguished near the tail. They adhere to the body by means of a particular transparent skin, which is in general very thin, but somewhat thicker near the neck, and extended loosely over the whole head: this skin is very easily destroyed, after which the scales falling, the body appears spotted (fig. 1.) When you look at them with the naked eye (fig. 2.) they appear as covered with very small grains; but viewed through a microscope (fig. 3.) the middle of them appears more elevated than the margin; and from the centre to the margin, close by each other, there are many lines or rays formed by small scales placed upon one another, like tiles upon a roof, the superior being always the nearer to the centre. This sort of scales, which may be called *umbonata*, are fastened to the body by very small vessels which are inserted in their middle; they are to be seen on the body only, not on the head nor the fins."

The anatomy of this fish comprehends some very remarkable circumstances, which, our author thinks, were never observed in any other species. When the skin is drawn off, there appears a thin membrane of a silver colour, which covers the muscles. The muscles being removed, we find the peritoneum, which lines the abdominal cavity, and is adherent to the swimming bladder by some elongations. It is of a silver hue, with some very small black points. The ventricle is not to be distinguished from the intestines by any other mark but by its size; its form is oblong; it is extended almost to the anus, from whence the intestinal duct has a retrograde course, and then descends again, having a little dilatation near the anus. On the vertebrae next the anus on the outside of the peritoneum is a kind of cavity of an oblong form, containing a reddish viscus, which he takes to be the kidney.

The first vertebra from the head has nothing very remarkable in its structure. The second has on each side an elongated and sharp apophysis, to the apex of which is annexed a small ligament. The third is very flat, and has on each side a kind of triangular and sharp apophysis, to which adheres a ligament as to the second. The fourth is remarkable in having a sharp apophysis on each side, articulated with the body of the vertebra; and under each of them is another articulated apophysis, flattish, thick, roundish at its extremities, and forked at its basis (fig. 5.) The fifth, which is strongly adherent to the former, has in its middle a bifid process. The sixth has in its middle a flattish elevation, sharp on each side. Between the extremity of the larger apophysis of the fourth vertebra is a bone, or rather a hard cartilage, which bears the figure of a kidney (fig. 6.) its convexity being turned towards the body of the ver-

tebra: its position is parallel to the bodies of the vertebrae; its motion is half circular; one of its parts, viz. the lowest, being in the cavity of the swimming bladder, to which it adheres by a thin membrane, so that no air can escape at that part. It is covered by membranes, which adhere strongly to its middle; in this part are fastened the two ligaments of the apophysis of the second and third vertebrae, of which we spoke before, and which are of a great tenuity. In the same point are fastened also two ligaments, each of which belongs to an oblong muscle parallel to each other, and fixed to the bones of the lowest and posterior part of the head (fig. 4.)

All this apparatus is certainly subservient to the purpose of swimming; but it is very remarkable, that if these parts are necessary to some animal function, they should not be found in all the individuals; "for I have seen (says our author) two, of which the vertebrae were not different from the vertebrae of the other species: which difference depends, perhaps, on the difference of sex. I am inclined to believe so; but the generation in this fish seems to be no less mysterious than that of the eel: I could never distinguish a male from a female in this species."

This fish commonly grows to the size of eight or nine inches. It is to be found in all the Mediterranean sea, and in great plenty in the Adriatic: its flesh is not of a good taste, rather coarse, as is that of all the species of fishes which, having no ventral fins, are obliged to make great efforts in swimming, and have consequently the muscles harder.

OPHIOGLOSSUM, ADDER'S TONGUE: A genus of the natural order of filices, belonging to the cryptogamia class of plants. The spike is articulated, flat, and turned to the two sides; with the articuli or joints opening across. There are seven species; of which the only remarkable one is the vulgatum, or common adder's-tongue, which is a native of several places of Britain, growing in meadows and moist pastures. The country-people make an ointment of the fresh leaves, and use it as a vulnerary to green wounds; which is a very ancient application, recommended by Matthioli, Tragus, and others.

OPHIOMANCY, in antiquity, the art of making predictions from serpents. Thus Calchas, on seeing a serpent devour eight sparrows with their dam, foretold the duration of the siege of Troy: and the seven coils of a serpent that was seen on Anchises's tomb, were interpreted to mean the seven years that Æneas wandered from place to place before he arrived at Latium.

OPHIORHIZA, in botany: A genus of the monogynia order, belonging to the pentandria class of plants; and in the natural method ranking under the 47th order, *Stellata*. The corolla is funnel-shaped; the capsule twin, bilocular, and polyspermous. There are two species; the most remarkable of which is the Asiaticum, or true lignum colubrinum. The root of this is known in the East Indies to be a specific against the poison of the most dreadful animal called the *hooded serpent*. There is a treatise in *Amœn. Acad.* tom. iv. upon this subject, wherein the author Joh. And. Darelus undertakes, from the description of such authors as had seen it upon the spot, to ascertain the plant from which the genuine root is taken. It appears in this account; that it had puzzled the Eu-

Ophioglossum
||
Ophiorrhiza

¹ **Ophioxylon** ^{Ophir} ropean physicians; and what had been sold in the shops for it, is the root of a very different plant, and of a poisonous nature.

The true root is called *mungus*, for the following reason.—There is a kind of weasel in the East Indies, called *mungutia* by the natives, *mungo* by the Portuguese, and *muncas* by the Dutch. This animal pursues the hooded serpent, as the cat does the mouse with us. As soon as the serpent appears, the weasel attacks him; and if she chances to be bit by him, she immediately runs to find a certain vegetable, upon eating which she returns, and renews the fight.—The Indians are of opinion that this plant is the mungos.

That celebrated traveller Kämpfer, who kept one of these weasels tame, that eat with him, lived with him, and was his companion wherever he went, says he saw one of these battles between her and the serpent, but could not certainly find out what root the weasel looked out for. But whether the weasel first discovered this antidote or not, it is an infallible remedy against the bite of the hooded serpent. And this he undertakes to ascertain.

OPHIOXYLON, in botany: A genus of the monœcia order, belonging to the polygamia class of plants; and in the natural method ranking with those of which the order is doubtful. The hermaphrodite calyx is quinquefid; the corolla quinquefid and funnel-shaped; with a cylindrical nectarium within its mouth.

¹ Different hypotheses respecting the situation of Ophir.

² Hypothesis of Mr Bruce

OPHIR, a country mentioned in scripture, from which Solomon had great quantities of gold brought home in ships which he sent out for that purpose; but where to fix its situation is the great difficulty, authors running into various opinions on that head. Some have gone to the West, others to the East Indies, and the eastern coasts of Africa, in search of it.—Mr Bruce the celebrated Abyssinian traveller has displayed much learning and ingenuity in settling this question of Biblical history. To the satisfaction of most of his readers he has determined Ophir to be Sofala, a kingdom of Africa, on the coast of Mosambique, near Zanguebar (see **SOFALA**). His reasons for this determination are so generally known, that it would be improper to repeat them here at length; because such as are not already acquainted with them may consult his book, which has been long in the hands of the public. He justly observes, that in order to come to a certainty where this Ophir was, it will be necessary to examine what scripture says of it, and to keep precisely to every thing like description which we can find there, without indulging our fancy farther. *1st*, Then, the trade to Ophir was carried on from the Elanitic gulph through the Indian ocean. *2^{dly}*, The returns were gold, silver, and ivory, but especially silver*. *3^{dly}*, The time of the going and coming of the fleet was precisely three years†, at no period more nor less.

* 1 Kings, 2. 22.
† 1 Kings, 2. 22.
2 Chron. 2. 21.

Now, if Solomon's fleet sailed from the Elanitic gulph to the Indian ocean, this voyage of necessity must have been made by monsoons, for no other winds reign in that ocean. And what certainly shows this was the case, is the precise term of three years in which the fleet went and came between Ophir and Ezion-gaber.

These mines of Ophir were probably what furnish-

ed the East with gold in the earliest times: great traces of excavation must therefore have appeared.

³ Ophir.

But John Dos Santos says, that he landed at Sofala in the year 1586; that he sailed up the great river Cuama as far as Tete, where, always desirous to be in the neighbourhood of gold, his order had placed their convent. Thence he penetrated for above 200 leagues into the country, and saw the gold-mines then working at a mountain called *Afura*. At a considerable distance from these are the silver mines of Chiconoua; at both places there is a great appearance of ancient excavations; and at both places the houses of the kings are built with mud and straw, whilst there are large remains of massy buildings of stone and lime.

3 Arguments in support of it.

Every thing then conspires to fix the Ophir of Solomon in the kingdom of Sofala, provided it would necessarily require neither more nor less than three years to make a voyage from Ezion-gaber to that place and Tarshish and return. To establish this important fact, our author observes, that the fleet or ship for Sofala, parting in June from Ezion-gaber (see **EZION-GABER**), would run down before the northern monsoon to Mocha (see **MOCHA**). Here, not the monsoon, but the direction of the gulph, changes; and the violence of the south-westers, which then reign in the Indian ocean, make themselves at times felt even in Mocha roads. The vessel therefore comes to an anchor in the harbour of Mocha; and here she waits for moderate weather and a fair wind, which carries her out of the straits of Babelmandeb, through the few leagues where the wind is variable.

Her course from this is nearly south-west, and she meets at cape Gardesfan a strong south-wester that blows directly in her teeth. Being obliged to return into the gulph, she mistakes this for a trade-wind; because she is not able to make her voyage to Mocha but by the summer monsoon, which carries her no farther than the straits of Babelmandeb, and then leaves her in the face of a contrary wind, a strong current to the northward, and violent swell.

The attempting this voyage with sails, in these circumstances, was absolutely impossible, as their vessels went only before the wind: if it was performed at all, it must have been by oars; and great havock and loss of men must have been the consequence of the several trials.

At last, philosophy and observation, together with the unwearied perseverance of man bent upon his own views and interest, removed these difficulties, and showed the mariners of the Arabian gulph, that these periodical winds, which in the beginning they looked upon as invincible barriers to the trading to Sofala, when once understood, were the very means of performing this voyage safely and expeditiously.

The vessel trading to Sofala sailed from the bottom of the Arabian gulph in summer, with the monsoon at north, which carried her to Mocha. There the monsoon failed her by the change of the direction of the gulph. The south-west winds, which blow without cape Gardesfan in the Indian ocean, forced themselves round the cape so as to be felt in the road of Mocha, and make it uneasy riding there. But these soon changed, the weather became moderate, and the vessel, we suppose in the month of August, was safe at anchor

Ophir.

Ophir.

anchor under cape Gardefan, where was the port which, many years afterwards, was called *Promontorium Aromaticum*. Here the ship was obliged to stay all November, because all these summer months the wind south of the cape was a strong south-wester, as hath been before said, directly in the teeth of the voyage to Sofala. But this time was not lost; part of the goods bought to be ready for the return was ivory, frankincense, and myrrh; and the ship was then at the principal mart for these.

Our author supposes, that in November the vessel sailed with the wind at north-east, with which she would soon have made her voyage: but off the coast of Melinda, in the beginning of December, she there met an anomalous monsoon at south-west, in our days first observed by Dr Halley, which cut off her voyage to Sofala, and obliged her to put into the small harbour of Mocha, near Melinda, but nearer still to Tarshish, which we find here by accident, and which we think a strong corroboration that we are right as to the rest of the voyage. In the annals of Abyssinia, it is said that Amda Sion, making war upon that coast in the 14th century, in a list of the rebellious Moorish vassals, mentions the chief of Tarshish as one of them, in the very situation where we have now placed him.

Solomon's vessel, then, was obliged to stay at Tarshish till the month of April of the second year. In May, the wind set in at north-east, and probably carried her that same month to Sofala. All the time she spent at Tarshish was not lost, for part of her cargo was to be brought from that place; and she probably bought, bespoke, or left it there. From May of the second year, to the end of that monsoon in October, the vessel could not stir; the wind was north-east. But this time, far from being lost, was necessary to the traders for getting in their cargo, which we shall suppose was ready for them.

The ship sails, on her return, in the month of November of the second year, with the monsoon south-west, which in a very few weeks would have carried her into the Arabian gulph. But off Mocha, near Melinda and Tarshish, she met the north-east monsoon, and was obliged to go into that port and stay there till the end of that monsoon; after which a south-wester came to her relief in May of the third year. With the May monsoon she ran to Mocha within the straits, and was there confined by the summer monsoon blowing up the Arabian gulph from Suez, and meeting her. Here she lay till that monsoon, which in summer blows northerly from Suez, changed to a south-east one in October or November, and that very easily brought her up into the Elanitic gulph, the middle or end of December of the third year. She had no need of more time to complete her voyage, and it was not possible she could do it in less.

Such is a very short and imperfect abstract of our author's reasons for placing Ophir in Sofala. If it excite the curiosity of our readers to consult his work, it will answer the purpose for which we have made it.

4.
Another hypothesis.

We are now to give another ingenious conjecture concerning the situation of Ophir and Tarshish, with

which we have been favoured by Dr Doig, the learned author of *Letters on the Savage State*, addressed to Lord Kames.

This respectable writer holds that Ophir was somewhere on the west coast of Africa, and that Tarshish was the ancient Bætica in Spain. His essay is not yet published; but he authorises us to give the following abstract of it: "The first time that *Ophir*, or rather *Aufir*, occurs in scripture, is in Gen. x. 29. where the sacred historian, enumerating the sons of Joktan, mentions Aufir as one of them." According to his account, the descendants of those 13 brothers settled all in a contiguous situation, from Mesha (the Mocha of the moderns) to Sepharah, a mountain of the east. Moses, as every one knows, denominates countries, and the inhabitants of countries, from the patriarch of whom those inhabitants descended. In describing the course of one of the branches of the river of paradise, the same Moses informs us that it encompassed the whole land of Havilah, &c. which abounded with fine gold, bdellium, and the onyx stone; and this land had its name from Havilah the 12th son of the patriarch Joktan. *Ophir* or *Aufir* was Havilah's immediate elder brother; and of course the descendants of the former, in all probability, fixed their habitation in the neighbourhood of those of the latter. If, then, the land of Havilah abounded with gold and precious stones, the land of Ophir undoubtedly produced the very same articles.

Here then we have the original Ophir; here was found the primary gold of Ophir; and here lay the Ophir mentioned in Job xi. 24. But as navigation was then in its infant state, the native land of gold mentioned by Job must have been much nearer home than that to which the fleets of Solomon and Hiram made their triennial voyages. That several countries on the south-east coast of Africa abounded with gold long after the era of Job, is evident from the testimony of Herodotus, Strabo, Diodorus Siculus, Ptolemy, Pomponius Mela, &c.; but that in these countries the Ophir of Solomon could not be situated, is plain, because his ships in the same voyage touched at Tarshish, which lay in a very different quarter.

The Abyssinian traveller has placed this *regio aurifera* in Sofala on the eastern coast of Africa, nearly opposite to the island of Madagascar. This hypothesis was current an hundred years before he was born; but I am persuaded (says our author) that it is not tenable. The Ophir of Solomon, in whatever part of Africa it lay, must have been well known, prior to his reign, both to the Phœnicians and the Edomites. These people navigated that monarch's fleet, and therefore could be no strangers to the port whither they were bound. That it was in Africa is certain; and that it was on the west coast of that immense peninsula, will appear more than probable, when we have ascertained the situation of Tarshish, and the usual course of Phœnician navigation. To these objects, therefore, we shall now direct our enquiries.

"Javan, the fourth son of the patriarch Japhet, had four sons, Elisah, *Tarshish*, Kittim, and Dodanim or Rodanim; among whose descendants were the isles of the Gentiles divided." The city of *Tarsus* on the coast of Cilicia, at once ascertains the region colonized by the descendants of Tarshish. But as much depends

6.
The situation must be ascertained by discovering that of Tarshish.

Ophir, depends upon determining the position of this country, I shall endeavour (says the Doctor) to fix it with all possible precision.

"In the first place, I must beg leave to observe, that there is not a single passage in any ancient author, sacred or profane, that so much as alludes to any city, district, canton, or country, of the name of Tarshish in the eastern parts of the world. The descendants of Javan, of whom Tarshish was one, are agreed on all hands to have extended their settlements towards the north-west, i. e. into Asia Minor, Italy, and Spain. The inhabitants of Tarshish are every where in scripture said to be addicted to navigation and commerce, in which they seem to have been connected with the

* Ps. xlviii. Tyrians and Phœnicians *, who were always said by the Jews to inhabit the isles of the sea. Indeed, in Hebrew geography, all the countries toward the north and west, which were divided from Judea by the sea,

† Gen. ii. 26 were called the isles of the sea †. Thus Isaiah: 'The burden of Tyre. Howl ye ships of Tarshish, for it is laid waste, so that there is no house, no entering in: from the land Chittim it is revealed unto them. Be still ye inhabitants of the isle, thou whom the merchants of Zidon, that pass over the sea, have replenished.' The land of Chittim was Macedonia, and often Greece, from which every one knows that the destruction of Tyre came; and that Tarshish was not an unconcerned spectator of that destruction, is obvious from the same prophet, who proceeds to say ‡: 'As at the report concerning Egypt, so shall they be sorely pierced at the report concerning Tyre. Pass over to Tarshish; howl ye inhabitants of the isle. Is this your joyous city?' It appears likewise from

§ xxvii. 12. Ezekiel §, that Tarshish was the merchant with whom Tyre traded for silver, iron, tin, and lead, and that this trade was carried on in fairs.

¶ If xxiii. passim.

7 The original Tarshish where situated. "From all these passages, it seems to be evident, that the descendants of Tarshish settled on the western coast of Asia Minor; that these people were addicted to navigation and commerce; that in the course of their traffic they were connected with the Tyrians and Phœnicians; that the commerce they carried on consisted of silver, iron, tin, and lead; that the people of Tarshish were connected with Kittim and the isles of the Gentiles, which are confessedly situated toward the north and west of Judea.

"But lest, after all, a fact so fully authenticated should still be called in question, I shall add one proof more, which will place the matter beyond the reach of doubt and controversy.

"When the prophet Jonah intended to flee from the presence of the Lord, in order to avoid preaching at Nineveh, let us see where the peevish deserter embarked. (Jonah i. 3.) 'And Jonah rose up to flee unto Tarshish, from the presence of the Lord, and went down to Joppa; and he found a ship going to Tarshish, and he paid the fare thereof, and went down into it, to go with them into Tarshish, from the presence of the Lord.' Every body knows that Joppa or Japhah stood upon the shore of the Mediterranean; of course the fugitive prophet had determined to go to some very distant region westward, and by that means to get as far from Nineveh as possible."

8 This not the Tarshish of Solomon. Having thus proved to a demonstration, that the original Tarshish was a region on the western coast of N^o 246.

Asia Minor, where either the patriarch of that name, or some of his immediate descendants, planted a colony, it remains to determine whether this was actually the country from which Solomon imported the vast quantities of silver mentioned by the sacred historian. That it was not, our author frankly acknowledges; and therefore, says he, we must look out for Solomon's Tarshish in some other quarter of the globe.

To pave the way for this discovery, he very justly observes, that it has at all times been a common practice to transfer the name of one country to another, in consequence of some analogy or resemblance between them. It has likewise often happened, that when a commodity was brought from a very distant country by a very distant people, the people to whom it was imported have taken it for granted that it was produced in the region from which it was immediately brought to them. Of the truth of this position no man acquainted with the Greek and Roman poets can for a moment entertain a doubt. Hence the *Affyrium animum* of Virgil, and the *Affyrium malabathrum* of Horace, though these articles were the product not of Assyria but of India. The Jews, who were as little acquainted with foreign countries as the Greeks and Romans, had very probably the same notions with them respecting articles of commerce; and if so, they would undoubtedly suppose, that the silver sold by the merchants of Tarshish was the product of that country. When this mistake came to be discovered, they very naturally transferred the name *Tarshish* from the country of the merchants to that of the articles which they imported. Let us now, says our author, try if we cannot find out where that country was.

It has been already shown, by quotations from Isaiah and Ezekiel, that the merchants of Tarshish traded in the markets of Tyre with silver, iron, lead, and tin. To these authorities, we shall add another from Jeremiah: "Silver (says that prophet) spread into plates is brought from Tarshish." "But in Spain (continues our learned dissertator), all those commodities were found in the greatest abundance. All the ancient authors who describe that region dwell with rapture on its silver mines. This fact is too generally known to need to be supported by authorities. Spain was then the region which furnished Solomon's traders with the immense mass of silver he is said to have imported. This was, one might say, the modern Tarshish; and indeed both Josephus and Eusebius are positive that the posterity of Tarshish actually peopled that country. If this was an early opinion, as it certainly was, the Jews would of course denominate Spain from the patriarch in question.

"I have shown above, that the inhabitants of Tarshish were strictly connected with the Kittim, or Grecians: I shall here produce an authority which will prove to a demonstration that the Kittim had extended their commerce into that part of Africa now called Barbary."

"The Prophet Ezekiel, (xxvii. 6.) describing the splendor and magnificence of Tyre, tells us, 'that the company of the Ashurites made her benches of ivory, brought from the isles of Kittim.' In the first place, I must observe, that there is probably a small error in the orthography of the word Ashurim. This term is every where in scripture translated Assyrians, which

9 The name of one country transferred to another.

^{to} Ophir. which translation is certainly just. But how the Assyrians could export ivory from the isles of Kittim, and fashion it into benches for the Tyrian mariners, is, in my opinion, a problem of no easy solution. The fact is, Ashurim should be Asherim, that is, the company of the men of Asher. The tribe of Asher obtained its inheritance in the neighbourhood of Tyre; (see Josh. xix. 28.) 'And Hebron, and Rehob, and Hammon and Canah, unto Zidon the great.' The companies of the tribe of the Asherites then, and not the Ashurim, were the people who manufactured the benches in question.

"Be that as it may, the ivory of which these implements were formed was imported from the isles of Kittim, that is, from Greece and its neighbourhood. These islands, it is certain, never produced ivory. They must therefore have imported it from some other country; but no other country, to which the Greeks and their neighbours could have extended their commerce, except the north of Africa, produced that commodity. The conclusion then is, that the maritime states of Asia Minor, Greece, and probably the Etruscans on the west coast of Italy, carried on a gainful commerce with Spain and Barbary at a very early period.

"We have now seen that the original Tarshish on the coast of Asia Minor did not produce the metals imported by Solomon's fleet; that no Tarshish is to be found in the eastern parts of the globe; that the Tarshish we are in quest of was undoubtedly situated somewhere towards the west of Judea: we have shown that the mercantile people of Asia Minor, Greece, and probably of Italy, actually imported some of those articles from the coast of Africa; we have hazarded a conjecture, that Spain was the modern Tarshish, and that very country from which Solomon imported his silver, and the Tyrians their silver, iron, tin, and lead. Let us now make a trial whether we cannot exhibit some internal proofs in support of the hypothesis we have above adopted.

"The ancients divided Spain into three parts, Bætica, Lusitania, and Tarvaconensis. Bætica is the modern Andalusia. It stretched along the Fretum Herculeum, or Straits of Gibraltar, to the mouth of Guadalquivir. This region is thought by some to have been the Elysian fields of the poets. The river Bætis, which divides it, is called *Tartessus*, by Aristotle, Strabo, Pausanias, Steph. Byzant. and Avianus. Here too we have a city and a lake of the same name. But Tartessus is positively the very same with Tarshish. The Phœnicians, by changing *schin* into *thau*, made it Tartish. The Greeks manufactured the rest, by changing Tartish into Tartis, and in process of time into *ταρτησσος*. That the Phœnicians actually changed *schin* into *thau* is certain; for Plutarch tells us in the life of Sylla, that in their language an ox was called *thor*, which is, no doubt, the same with the Hebrew *shor*.

^{to} Tarshish Spanish Bætica. "From this deduction, it appears highly probable at least, that the Spanish Bætica was originally called *Tarshish*. Indeed this similarity of names has operated
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ed so powerfully on the learned Bochart, and on some other moderns of no mean figure, that they have positively affirmed, as Josephus had done before them, that the patriarch Tarshish actually settled in that country. This I should think not altogether probable; but that his descendants who settled on the coast of Asia Minor colonized Bætica, and carried on an uninterrupted commerce to that country, along with the Phœnicians, for many centuries after it was peopled, and that from the circumstances above narrated, it was denominated *Tarshish*, are facts too palpable to admit of contradiction.

"Let us now see whether this Bætica, where I have endeavoured to fix the situation of the Tarshish of the scriptures, was actually furnished with those articles of commerce which are said to have been imported from that country. To enlarge on this topic would be altogether superfluous. Diodorus Siculus, Strabo, Polybius, Pliny, Solinus, and, in one word, all the Greek and Roman historians who have mentioned that region, have unanimously exhibited it as the native land of silver, iron, and tin: to these, contrary to the opinions of the celebrated modern traveller, they likewise add gold in very large quantities."

Our author having thus ascertained the situation of Tarshish, proceeds to prove, by a mass of evidence too large for our insertion, that the Edomites and Tyrians had doubled the Cape, and almost encompassed Africa, long before the era of Solomon. Then referring to 1 Kings, chap. ix. and x. 2 Chron. viii. ix. 2 Kings xxii. and 2 Chron. xx. he observes, that from these authorities it appears indubitable, that the fleets of Solomon and Hiram sailed from Eloth and Ezion-geber; that the voyages to Ophir and Tarshish were exactly the same, performed at one and the same time, by the very same fleet; which must necessarily have encompassed the peninsula of Africa before it could arrive at the country of Tarshish. This being the case, the traders might easily enough collect the gold on the coast of Guinea, or on what is now vulgarly called the *Gold Coast*. The ivory they might readily enough procure on the Barbary coast, opposite to Tarshish. In Africa, too, they might hunt apes, monkeys, baboons, &c; and peacocks, or rather parrots, and parroquets, they might surprise in the forests which abounded on the coast. In Spain, silver, iron, lead, and tin, were, one may say, the native produce of the soil. Even at this early period, the Phœnician navigators had discovered the Cassilerides, or Scilly islands and Cornwall; and from that region, in company with the merchants, may have supplied them with that rare commodity.

"I have supposed that the navy of Solomon and Hiram collected their gold in the course of their voyage somewhere on the coast of Africa, beyond the Cape, for the following reasons: Had they found the golden fleece at Sofala (A), or any part of the coast of Africa, they would have chosen to return and unlade at Eloth or Ezion-geber, rather than pursue a long and dangerous course, quite round Africa, to Tarshish; to which last country they might have shaped their
F f course

(A) That Sofala opposite to the island of Madagascar was Ophir, was an ancient conjecture. See Bochart. Chan. l. 2. cap. 27. p. 160. 4to.

Ophir.

course much more commodiously from Zidon, Tyre, Joppa, &c. But being obliged to double the Cape in quest of some of these articles which they were enjoined to import, they pushed onward to Tarshish, and returned by the pillars of Hercules to Tyre, or perhaps to Joppa, &c. Their next voyage commenced from one or other of these ports, from which they directed their course to Tarshish; and having taken in part of their lading there, they afterwards coasted round Africa, and so arrived once more at Eloth or Ezion-geber.

"Let us now attend to the space of time in which these voyages were performed. We are told expressly (2 Chron ix. 21.) that once every three years came the ships of Tarshish, &c. This is exactly the time one would naturally imagine necessary to perform such a distant voyage, at a period when navigation was still in its infancy, and mariners seldom adventured to lose sight of the coast. Of this we have an irrefragable proof in the history of a voyage round the very same continent, undertaken and accomplished in the very same space of time, about two centuries after.

"We learn from Herodotus, l. 2. cap. 149. that Necho, one of the later kings of Egypt, whom the scripture calls *Pharaoh Necho*, built a great number of ships, both on the Red Sea and the Mediterranean. The same historian, lib. iv. cap. 42. informs us, that this enterprising monarch projected a voyage round the continent of Africa, which was actually accomplished in the space of three years. In the conduct of this enterprise, he employed Phœnician mariners, as Solomon had done before him. These, we may suppose, were assisted in the course of this navigation by charts or journals, or at least by traditional accounts derived from their ancestors: These navigators (says the historian) took their departure from a port on the Red Sea, and sailing from thence into the southern ocean, and, in the beginning of autumn, landing on the coast of Africa, there they sowed some grain which they had carried out with them on board their vessels. In this place they waited till the crop was ripened; and, having cut it down, they proceeded on their voyage. Having spent two years in this navigation, in the third they returned to Egypt, by the pillars of Hercules. These mariners, adds the author, reported a fact, which, for his part, he could by no means believe to be true; namely, that in one part of their course their shadows fell on their right; a circumstance which gives considerable weight to the truth of the relation."

"Let it now be observed, that Phœnician mariners navigated the fleet of Solomon: the same people conducted that of Necho: the fleet of Necho spent three years in the course of its voyage; that of Solomon did the same in its course about two centuries before: the fleet of Necho sailed from a port on the Red sea; that of Solomon took its departure from Eloth or Ezion-geber, situated on the same sea; the fleet of the former returned by the pillars of Hercules; that of the latter, according to the hypothesis, pursued the very same route. Such a coincidence of similar circumstances united with those adduced in the preceding part of this article, seem to prove almost to a demonstration, that the navy of Hiram and Solomon

performed a voyage round Africa, in that age, in the same manner as that of Necho did two centuries after. Ophir.

"Upon the whole, I conclude, that the original Ophir, which is really Aufir or Aufr, was situated on the south of Arabia Felix, between Sheba and Havilah, which last was encompassed by one of the branches of the river of Paradise: that the name Ophir, i.e. Aufr, was, in consequence of its resemblance, in process of time transferred to a region on the coast of Africa; and that from it first *Afer* and then Africa was denominated: that the primitive Tarshish was Cilicia, and that the Jews applied this name to all the commercial states on the coast of Asia Minor, and perhaps of Italy, there being strong presumptions that the Tyrrhenians were colonists from Tarshish; that Bœtica, and perhaps some other regions of Spain, being planted with colonies from Tarshish, likewise acquired the name of Tarshish; that the Tyrians were strictly connected with the merchants of Tarshish in their commercial enterprizes; that Tarshish was certainly situated westward from Judea, Phœnicia, &c.; that no other country in the western quarters produced the commodities imported by the two kings, except Spain and the opposite coasts; that this country, in those ages, produced not only silver, iron, tin, and lead, but likewise gold in great abundance; that the merchants of Kittim imported ivory, of which the Asherites made benches for the Tyrians; which commodity they must have purchased on the coast of Barbary, where the Jews and Phœnicians would find the same article; that Tarshish being situated in Spain, it was impossible for a fleet sailing from Eloth or Ezion-geber, to arrive at that country without encompassing Africa; that, of course, the fleet in question did actually encompass that continent; that the Ophir of Solomon must have been situated somewhere on the coast of Africa, to the west of the Cape, because from it the course to Tarshish was more eligible than to return the same way back to Ezion-geber."

Our author supports this conclusion by many other arguments and authorities, which the limits prescribed us will not permit us to detail; but perhaps the article might be deemed incomplete, if we did not show how he obviates an objection that will readily occur to his theory. "If the original Ophir was seated on the coast of Arabia Felix, and the modern region of the same name on the west coast of Africa, it may be made a question, how the latter country came to be denominated from the former? Nothing (says our author) can be more easy than to answer this question. The practice of adapting the name of an ancient country to a newly discovered one, resembling the other in appearance, in situation, in figure, in distance, in the nature of the climate, productions, &c. has ever been so common, that to produce instances would be altogether superfluous. The newly discovered region on the coast of Africa abounded with the same species of commodities by which the original one was distinguished; and, of course, the name of the latter was annexed to the former."

Whether Mr Bruce's hypothesis or Dr Doig's, respecting the long disputed situation of Solomon's Ophir, be the true one, it is not for us to decide. Both are plausible

11
Ophir situated on the coast of Africa, west of the Cape.

12
An objection answered.

Ophira plausible, both are supported by much ingenuity and uncommon erudition; but we do not think that the arguments of either writer furnish a complete confutation of those adduced by the other. *Sub judice lis est.*

OPHIRA, in botany: A genus of the monogynia order, belonging to the octandria class of plants. The involucre is bivalvular and triflorous; the corolla tetrapetalous above; the berry unilocular.

OPHITES, in natural history, a sort of variegated marble, of a dusky-green ground, sprinkled with spots of a lighter green, otherwise called *serpentine*. See the article MARBLE.

OPHITES, in church-history, Christian heretics, so called both from the veneration they had for the serpent that tempted Eve, and the worship they paid to a real serpent: they pretended that the serpent was Jesus Christ, and that he taught men the knowledge of good and evil. They distinguished between *Jesus* and *Christ*: Jesus, they said, was born of the Virgin, but Christ came down from heaven to be united with him; Jesus was crucified, but Christ had left him to return to heaven. They distinguished the God of the Jews, whom they termed *Jaldabaoth*, from the supreme God: to the former they ascribed the body, to the latter the soul of men. They had a live serpent, which they kept in a kind of cage; at certain times they opened the cage-door, and called the serpent: the animal came out, and mounting upon the table, twined itself about some loaves of bread; this bread they broke and distributed it to the company, who all kissed the serpent: this they called their *Eucharist*.

OPHRYS, TWYBLADE: A genus of the diandria order, belonging to the gynandria class of plants; and in the natural method ranking under the 7th order, *Orchideæ*. The nectarium is a little carinated below. The species are numerous; but the most remarkable are the following:

1. The *ovata*, *oval-leaved ophrys*, or *common twy-blade*, hath a bulbous, fibrated root; crowned by two oval, broad, obtuse, veined, opposite leaves; an erect, succulent, green stalk, six or eight inches high, naked above, and terminated by a loose spike of greenish flowers, having the lip of the nectarium bifid. The flowers of this species resemble the figure of gnats.

2. The *spiralis*, *spiral orchis*, or *triple ladies-tresses*, hath bulbous, oblong, aggregated roots; crowned by a cluster of oval, pointed, ribbed leaves; erect simple stalks, half a foot high; terminated by long spikes of white odoriferous flowers, hanging to one side, having the lip of the nectarium entire, and crenated.

3. The *nidus-avis*, or *bird's-nest*, hath a bulbous, fibrated, clustered root; upright, thick, succulent stalks, a foot high, sheathed by the leaves, and terminated by loose spikes of pale-brown flowers; having the lip of the nectarium bifid.

4. The *anthropophora*, *man-shaped ophrys*, or *man-orchis*, hath a roundish bulbous root, crowned with three or four oblong leaves; upright thick stalks, rising a foot and a half high; adorned with narrow leaves, and terminated by loose spikes of greenish flowers, representing the figure of a naked man; the lip of the nectarium linear tripartite, with the middle segment longest and bifid. There is a variety with brownish flowers tinged with green.

5. The *insectifera*, or *insect-orchis*, hath two roundish bulbous roots, crowned with oblong leaves; erect leafy stalks, from six to 10 or 12 inches high, terminated by spikes of insect-shaped greenish flowers, having the lip of the nectarium almost five-lobed. This wonderful species exhibits flowers in different varieties, that represent singular figures of flies, bees, and other insects; and are of different colours in the varieties.

6. The *monorchis*, or *musky ophrys*, hath a roundish bulbous root; crowned with three or four oblong leaves; an erect naked stalk, six inches high; terminated by a loose spike of yellowish, musky-scented flowers.

All these six species of ophrys flower in summer, at different times in different sorts, from May until July; and in most of the sorts exhibit a singularly curious appearance. The plants are all perennial in root, which are of the bulbous fleshy kind, from which the flower-stalks rise annually in spring, and decay in autumn; at which period is the proper time for removing the roots from one place to another. They all grow wild in Britain, &c.; are residents of woods, bogs, marshy grounds, sterile pastures, chalky soils, and the like places, where they flourish and display their singular flowers in great abundance, from which places they are introduced into gardens for variety; and having procured some plants at the proper season, and planted them in soils and situations somewhat similar to that where they naturally grow, the roots will abide for several years, and flower annually.

As to their propagation, it may be tried by seed in a shady border, as soon as it is ripe; likewise by off-sets from the root, though they multiply sparingly in gardens: however, roots of some standing may be examined at the proper season, and any off-sets separated and planted in the proper places.

OPHTHALMOSCOPY, a branch of physiognomy, which deduces the knowledge of a man's temper and manner from the appearance of his eyes.

OPHTHALMIA, in medicine, an inflammation of the membranes which invest the eye; especially of the adnata, or albuginous coat. See MEDICINE, n° 175.

OPIATES, medicines of a thicker consistence than a syrup, prepared with opium scarcely fluid. They consist of various ingredients, made up with honey or syrup; and are to be used for a long time either for purgative, alterative, or corroborative intentions.

The word *opiate* is also used, in general, for any medicine given with an intention to procure sleep, whether in the form of electuaries, drops, or pills.

OPINION is that judgment which the mind forms of any proposition for the truth or falsehood of which there is not sufficient evidence to produce science or absolute belief.

That the three angles of a plane triangle are equal to two right angles, is not a matter of *opinion*, nor can it with propriety be called an object of the mathematician's *belief*: he does more than believe it; he *knows* it to be true. When two or three men, under no temptation to deceive, declare that they were witnesses of an uncommon, though not preternatural event, their testimony is complete evidence, and produces absolute *belief* in the minds of those to whom it is given;

Opinion
||
Opium.

but it does not produce *science* like rigid demonstration. The fact is not doubted, but those who have it on report do not *know* it to be true, as they know the truth of propositions intuitively or demonstrably certain. When one or two men relate a story including many circumstances to a third person, and another comes who positively contradicts it either in whole or in part, he to whom those jarring testimonies are given, weighs all the circumstances in his own mind, balances the one against the other, and lends an assent, more or less wavering, to that side on which the evidence appears to preponderate. This assent is his *opinion* respecting the facts of which he has received such different accounts.

Opinions are often formed of events not yet in being. Were an officer from the combined armies, which *July 1793* are just now * besieging Valenciennes, to come into the room where we are writing, and tell us that those armies are in good health and high spirits; that every shot which they fire upon the fortress produces some effect; and that they have plenty of excellent provisions, whilst the besieged are perishing by hunger; we should absolutely *believe* every fact which he had told us upon the evidence of his testimony; but we could only be of *opinion* that the garrison must soon surrender. In forming opinions of this kind, upon which, in a great measure, depends our success in any pursuit, every circumstance should be carefully attended to, and our judgments guided by former experience. Truth is a thing of such importance to man, that he should always pursue the best methods for attaining it; and when the object eludes all his researches, he should remedy the disappointment, by attaching himself to that which has the strongest resemblance to it; and that which most resembles truth is called *probability*, as the judgment which is formed of it is termed *opinion*. See PROBABILITY.

OPITS, or OPITIUS (Martin), a celebrated German poet, born at Breslaw in 1507. He acquired great fame by his Latin, and more by his German poems; and, retiring to Dantzic, wrote a history of the ancient Daci: he died of the plague in 1639.

OPITS (Henry), a learned Lutheran divine, born at Altenburg in Misnia in 1642. He was professor of theology and of the oriental languages at Kiel, where he acquired great reputation by a variety of excellent works concerning oriental literature and Hebrew antiquities. He died in 1712.

OPIUM, in the materia medica, is an inspissated juice, partly of the resinous and partly of the gummy kind, brought to us in cakes from eight ounces to a pound weight. It is very heavy, of a dense texture, and not perfectly dry; but, in general, easily receives an impression from the finger: its colour is a brownish yellow, so very dark and dusky that at first it appears black: it has a dead and faint smell, and its taste is very bitter and acrid. It is to be chosen moderately firm, and not too soft; its smell and taste should be very strong, and care is to be taken that there be no dirty or stony matter in it.

Opium is the juice of the papaver album, or white poppy, with which the fields of Asia Minor are in many places sown, as ours are with corn. When the heads are near ripening, they wound them with an in-

strument that has five edges, which on being stuck into the head makes at once five long cuts in it; and from these wounds the opium flows, and is next day taken off by a person who goes round the field, and put up in a vessel which he carries fastened to his girdle; at the same time that this opium is collected, the opposite side of the poppy-head is wounded, and the opium collected from it the next day. They distinguish, however, the produce of the first wounds from that of the succeeding ones; for the first juice afforded by the plant is greatly superior to what is obtained afterwards. After they have collected the opium, they moisten it with a small quantity of water or honey, and work it a long time upon a flat, hard, and smooth board, with a thick and strong instrument of the same wood, till it becomes of the consistence of pitch; and then work it up with their hands, and form it into cakes or rolls for sale.

Opium at present is in great esteem, and is one of the most valuable of all the simple medicines. In its effects on the animal system, it is the most extraordinary substance in nature. It touches the nerves as *Leake's Essay on the Diseases of the Viscera.* it were by magic and irresistible power, and steepens the senses in forgetfulness; even in opposition to the determined will of the philosopher or physiologist, apprised of its narcotic effect.

The modification of matter is infinite; and who shall truly say by what peculiar or specific configuration of its parts, opium, even in the quantity of a single grain, administered to the human body, shall assuage the most raging pain, and procure profound sleep?

The action of matter upon matter, thus exemplified in the effect of opium on the animal system, is not less astonishing and incomprehensible, than that of spirit upon matter or the agency of mind on the motive powers of the body.

The first effects of opium are like those of a strong, stimulating cordial, but are soon succeeded by universal languor or irresistible propensity to sleep, attended with dreams of the most rapturous and enthusiastic kind. After those contrary effects are over, which are generally terminated by a profuse sweat, the body becomes cold and torpid; the mind pensive and desponding; the head is affected with stupor, and the stomach with sickness and nausea.

It is not our business, neither is it in our power, to reconcile that diversity of opinion which has lately prevailed concerning the manner in which opium produces its effects; or to determine whether it acts simply on the brain and nerves, or, according to the experiments of Fontana, on the mass of blood only.

Opium is the most sovereign remedy in the materia medica, for easing pain and procuring sleep, and also the most certain antispasmodic yet known; but, like other powerful medicines, becomes highly noxious to the human constitution, and even mortal, when improperly administered. Its liberal and long continued use has been observed greatly to injure the brain and nerves, and to diminish their influence on the vital organs of the body. By its first effects, which are exhilarating, it excites a kind of temporary delirium, which dissipates and exhausts the spirits; and, by its subsequent narcotic power, occasions confusion of ideas and loss of memory, attended with nausea, giddiness, headach,

Opium. headach, and constipation of the bowels; in a word, it seems to suspend or diminish all the natural secretions and excretions of the body, that of perspiration only excepted.

Those who take opium to excess become enervated and soon look old; when deprived of it, they are faint, and experience the languor and dejection of spirits common to such as drink spirituous liquors in excess; to the bad effects of which it is similar, since, like those, they are not easily removed without a repetition of the dose.

By the indiscriminate use of that preparation of opium called *Godfrey's cordial*, many children are yearly cut off; for it is frequently given dose after dose, without moderation, by ignorant women and mercenary nurses, to silence the cries of infants and lull them to sleep, by which they are at last rendered stupid, inactive, and rickety.

Opium is universally known to be used as a luxury in the east. Mr Grose informs us, that most of the hard-labouring people at Surat, and especially the porters, take great quantities of this drug, which, they pretend, enables them to work, and carry heavier burdens than they otherwise could do. Some of these, our author assures us, will take more than an ounce at a time without detriment. Many people in opulent circumstances follow the same custom, but with very different motives. Some use it merely for the sake of the pleasing delirium it occasions; others for venereal purposes, as by this means they can lengthen the amorous congress as much as they please, though they thus are certain to bring on an absolute impotency and premature old age at last. For this purpose it is usually taken in milk; and when they have a mind to check or put an end to its operation, they swallow a spoonful or two of lime juice, or any similar acid.

Besides these effects of opium, it is said by the Indians to have a very singular one in bringing on a seeming heaviness of the head and sleepiness of the eye, at the same time that it really produces great watchfulness. It is also considered as a great inspirer of courage, or rather insensibility to danger; so that the commanders make no scruple of allowing large quantities of it to the soldiers when they are going to battle or engaged in any hazardous enterprize.

The best opium in the world is said to come from Patna on the river Ganges, where, at least, the greatest traffic of it is made, and from whence it is exported all over India; though in some parts, especially on the Malay coasts, it is prohibited under pain of death, on account of the madness, and murders consequent upon that madness, which are occasioned by it; notwithstanding which severe prohibition, however, it is plentifully smuggled into all these countries.—The soil about the Ganges is accounted best for producing the strongest kind of opium; of which the following remarkable instance is related. “A nabob of these parts having invited an English factory to an entertainment, a young gentleman, a writer in the company's service, sauntering about the garden, plucked a poppy and sucked the head of it. In consequence of this he fell into a profound sleep; of which the nabob being apprised, and likewise informed of the particular bed out of which he had taken the flower, expressed his sorrow; acquainting his friends at the same time that

the poison was too strong to admit of any remedy; which accordingly proved true, and the unfortunate gentleman never awaked.”

Opium applied externally is emollient, relaxing, and discutient, and greatly promotes suppuration: if long kept upon the skin, it takes off the hair, and always occasions an itching in it; sometimes it exulcerates it, and raises little blisters, if applied to a tender part. Sometimes, on external application, it allays pain, and even occasions sleep: but it must by no means be applied to the head, especially to the sutures of the skull; for it has been known to have the most terrible effects in this application, and even to bring on death itself.

It appears, too, from some curious experiments made by Dr Leigh, to act as the most powerful of all styptics. “Having laid bare the crural artery of a rabbit (says the Doctor), I divided it, when the blood instantly flew out with considerable velocity; some of a strong solution was then applied to the divided artery, the ends of which in a short space of time contracted, and the hæmorrhagy ceased. The same experiment was performed on the brachial artery with like success.”

The effects of a strong solution of opium upon the heart, appears from the same experiments to be very extraordinary. “I opened the thorax of a rabbit (says the Doctor), and by dissection placed the heart in full view; the aorta was then divided, and the animal bled till it expired. After the heart had remained motionless ten minutes, and every appearance of life had ceased for the same length of time, I poured on the heart a quantity of my strong solution; it was instantly thrown into motion, which continued two minutes: I then added more of the solution, and the action was again renewed. By thus repeating my applications, the motions of the heart were supported more than ten minutes. I afterwards opened the thorax of a rabbit, and, without doing any injury to the large blood-vessels, placed the heart in view. A quantity of my strong solution was then applied to it, which so accelerated the motions as to render it impossible to number them: by renewing the application, these were continued for some considerable time. The surface of the heart now appeared uncommonly red, and continued so some time.”

Opium contains gum, resin, essential oil, salt, and earthy matter; but its *narcotic* or somniferous power has been experimentally found to reside in its *essential oil*.

OPOBALSAMUM, in the materia medica. Opobalsam, or balm of Gilead. See AMYRIS.

Mr Bruce, the celebrated traveller, whom we have frequently had occasion to introduce to our readers with that praise to which we think his labours have fully intitled him, employs several pages of his Appendix in ascertaining the antiquity and native soil of the balsam-tree, with other particulars of that nature; after which he gives us the following account of the opobalsamum, or juice flowing from it: “At first when it is received into the bottle or vase from the wound from whence it issues, it is of a light, yellow colour, apparently turbid, in which there is a whitish cast, which I apprehend are the globules of air that pervade the whole of it in its first state of fermentation; it then appears very light upon shaking. As it settles and cools, it turns clear, and loses that milkiness which

*Opium,
Opobalsamum.*

An experimental enquiry into the properties of opium, &c.

Opobalsamum,
Opocalpasum

it first had when flowing from the tree into the bottle. It then has the colour of honey, and appears more fixed and heavy than at first. After being kept for years, it grows a much deeper yellow, and of the colour of gold. I have some of it, which, as I have already mentioned in my travels, I got from the Cadi of Medina in the 1768; it is now still deeper in colour, full as much so as the yellowest honey. It is perfectly fluid, and has lost very little either of its taste, smell, or weight. The smell at first is violent and strongly pungent, giving a sensation to the brain like to that of volatile salts when rashly drawn up by an incautious person. This lasts in proportion to its freshness; for being neglected, and the bottle uncorked, it quickly loses this quality, as it probably will at last by age, whatever care is taken of it.

"In its pure and fresh state it dissolves easily in water. If dropped on a woollen cloth, it will wash out easily, and leaves no stain. It is of an acrid, rough, pungent taste; is used by the Arabs in all complaints of the stomach and bowels, is reckoned a powerful antiseptic, and of use in preventing any infection of the plague. These qualities it now enjoys, in all probability, in common with the various balsams we have received from the new world, such as the balsam of Tolu, of Peru, and the rest; but it is always used, and in particular esteemed by the ladies, as a cosmetic: As such it has kept up its reputation in the east to this very day. The manner of applying it is this: You first go into the tepid bath till the pores are sufficiently opened; you then anoint yourself with a small quantity, and as much as the vessels will absorb. Never-fading youth and beauty are said to be the consequences of this. The purchase is easy enough. I do not hear that it ever has been thought restorative after the loss of either."

OPOCALPASUM, OPOCARBASUM, or APOCALPASUM; a gummy resinous substance, which has a strong resemblance to the best liquid myrrh, and which in the time of Galen they mixed with myrrh. It was difficult, according to this writer, to distinguish the one from the other unless by their effects. It was a poisonous juice, which frequently produced lethargy and sudden strangling. He declares, that he has known several persons who died in consequence of inadvertently taking myrrh in which there was a mixture of opocarbassum. Perhaps it was only a juice composed of a solution of euphorbia, in which drops of opium were macerated. Poisons of this kind have from time immemorial been as common in Africa as that of arrows poisoned with the juice of the manzanilla is in America.

Mr Bruce, the Abyssinian traveller, says, that he saw in a Mahometan village a large tree, which was so covered with knots and balls of gum on the upper part of the trunk and on the large branches, that it had a monstrous appearance. From some inquiries which he made on this subject, he found that certain merchants had brought this tree from the country of the good myrrh, which is Troglodytria (for it does not grow in Arabia), and that they had planted it for the sake of its gum; with which these Mussulmen starch the blue stuffs of Surat, which they receive damaged from Mocha, in order to barter them with the Galla and the Abyssinians. This tree is called *fassa*; and Mr Bruce declares that he has seen it completely covered with beautiful crimson flowers of a very uncom-

mon structure. The same traveller observes, that the fassa gum is well calculated, both on account of its abundance and its colour, to augment the quantity of myrrh; and he is the more confirmed in his opinion, because every thing leads him to think that no other gummiiferous tree, possessed of the same properties with the fassa, grows in the myrrh country. In short, he thinks it almost beyond a doubt that the gum of the fassa-tree is the opocalpasum; and he supposes Galen mistaken in ascribing any fatal property to this drug; and that many were believed to be killed by it, whose death might, perhaps, with more justice, have been placed to the account of the physician. Mr Bruce adds, that though the Troglodites of the myrrh country are at present more ignorant than formerly, they are nevertheless well acquainted with the properties of their simples; and that while they wish to increase the sale of their commodities, they would never mix with them a poison which must necessarily diminish it. In this we accede to his opinion; but we must differ from him when he says, that no gum or resin with which we are acquainted is a mortal poison: the savages of both hemispheres are acquainted with but too many of them. The gum of the fassa-tree, according to Mr Bruce, is of a close smooth grain, of a brown dull colour, but sometimes very transparent; it swells and becomes white in water; it has a great resemblance in its properties to gum tragacanth, and may be eaten with all safety. From all this it appears that the opocalpasum mentioned by Pliny is not the fassa gum described by Mr Bruce.

OPOPANAX, in the materia medica, is a gum-resin of a tolerably firm texture, usually brought to us in loose granules or drops, and sometimes in large masses, formed of a number of these connected by a quantity of matter of the same kind; but these are usually loaded with extraneous matter, and are greatly inferior to the pure loose kind. The drops or granules of the fine opopanax are on the outside of a brownish red colour, and of a dusky yellowish or whitish colour within: they are of a somewhat unctuous appearance, smooth on the surface; and are to be chosen in clear pieces, of a strong smell and acrid taste.

This gummy substance is obtained from the roots of an umbelliferous plant, which grows spontaneously in the warmer countries, and bears the colds of this. The juice is brought from Turkey and the East Indies; and its virtues are those of an attenuating and aperient medicine. Boerhaave frequently employed it, along with ammoniacum and galbanum, in hypocondriacal disorders, obstructions of the abdominal viscera, and suppressions of the menstrual evacuations from a sluggishness of mucous humours, and a want of due elasticity of the solids: with these intentions it is an useful ingredient in the pilulæ gummosæ and compound powder of myrrh of the London pharmacopœia, but it is not employed in any composition of the Edinburgh. It may be given by itself in the dose of a scruple, or half a dram: a whole dram proves in many constitutions gently purgative: also dispels flatulencies, is good in asthmas, in inveterate coughs, and in disorders of the head and nerves.

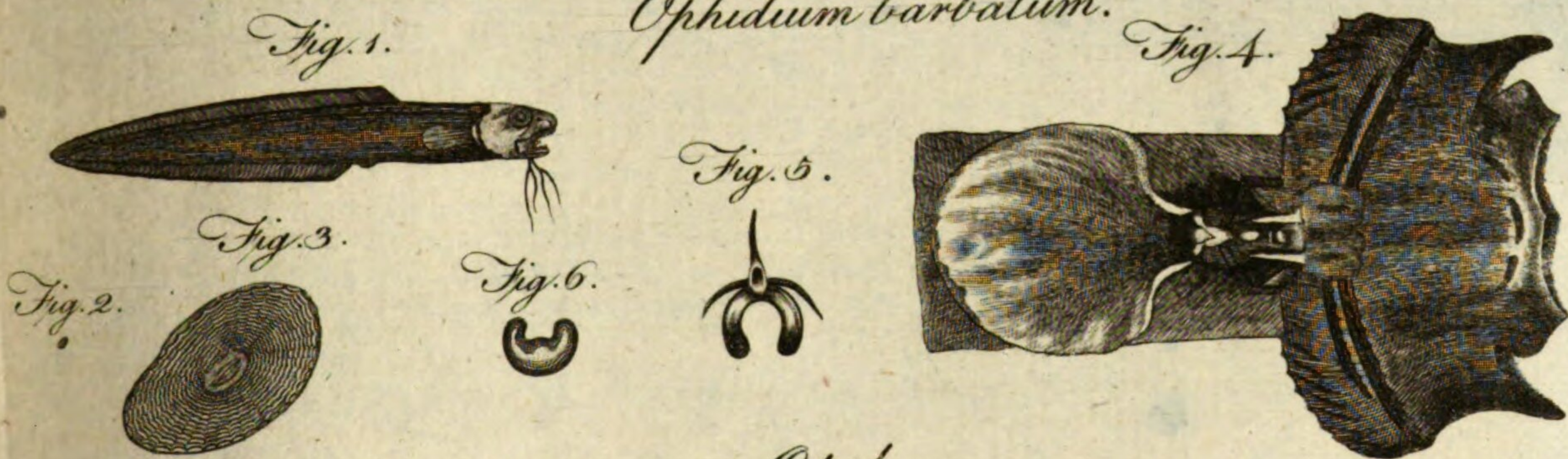
Doctor Woodville, in his Medical Botany, gives the following account of this vegetable. "It is of the *digynia* order, and *pentendria* class of plants: the root is perennial,

Opocalpasum,
Opopanax

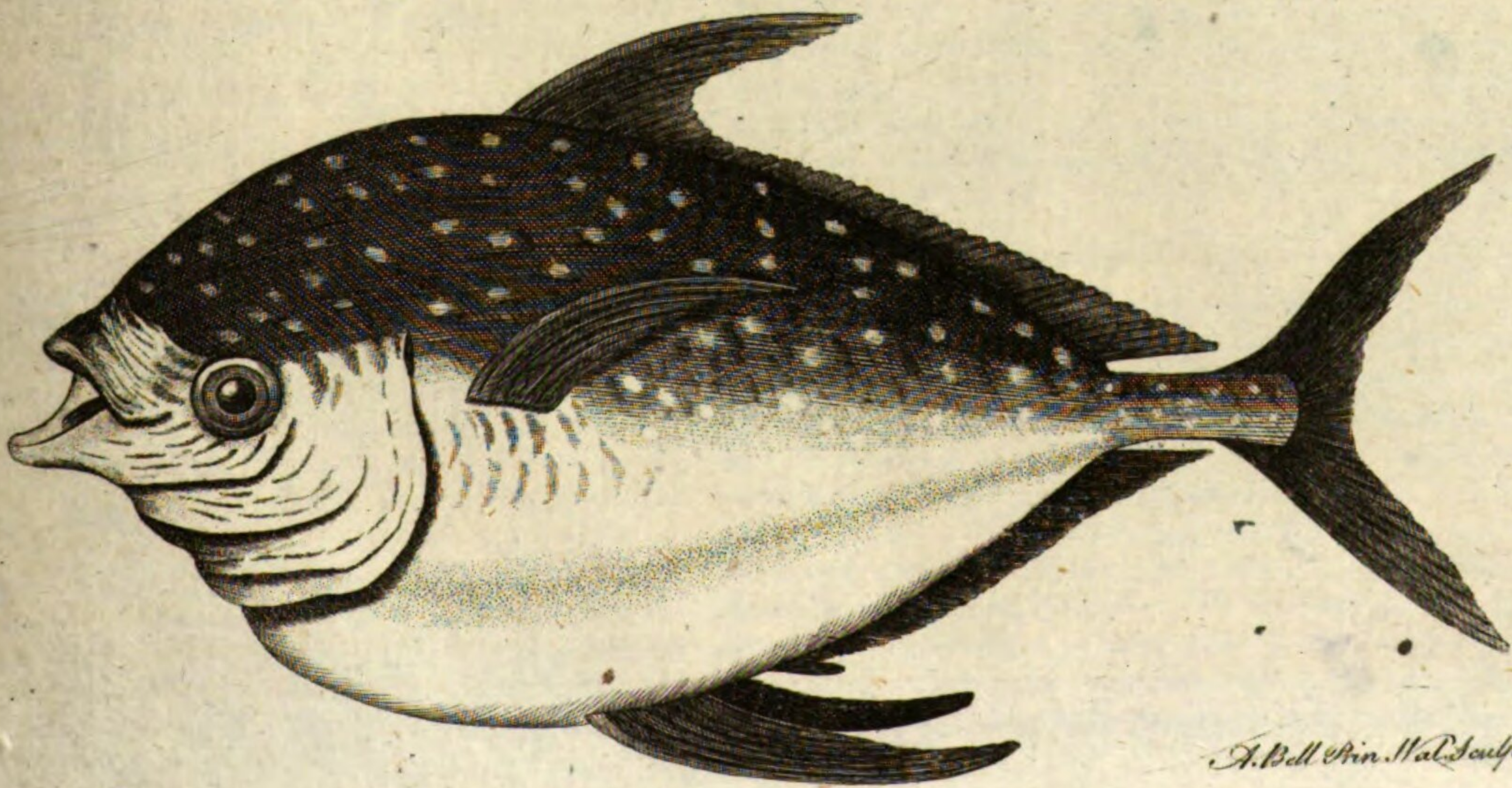
Opoponax,
a species of *Pastinaca*.



Ophidium barbatum.



Opah.



Opopanax. perennial, thick, fleshy, tapering like the garden parsnep: the stalk is strong, branched, rough towards the bottom, and rises seven or eight feet in height; the leaves are pinnated, consisting of several pairs of pinnæ, which are oblong, ferrated, veined, and towards the base appear unformed on the upper side: the flowers are small, of a yellowish colour, and terminate the stem and branches in flat umbels; the general and partial umbels are composed of many radii; the general and partial involucre are commonly both wanting; all the florets are fertile, and have an uniform appearance; the petals are five, lance-shaped, and curled inwards; the five filaments are spreading, curved, longer than the petals, and furnished with roundish antheræ; the germen is placed below the corolla, supporting two reflexed styles, which are supplied with blunt stigmata; the fruit is elliptical, compressed, divided into two parts, containing two flat seeds, encompassed with a narrow border. See Plate CCCLI. It is a native of the south of Europe, and flowers in June and July.

"This species of parsnep was cultivated in 1731 by Mr P. Miller, who observes, that its 'roots are large, sweet, and accounted very nourishing,' therefore recommended for cultivation in kitchen-gardens. It bears the cold of our climate very well, and commonly maturates its seeds, and its juice here manifests some of those qualities which are discovered in the officinal *opopanax*; but it is only in the warm regions of the east, and where this plant is a native, that its juice concretes into this gummy resinous drug. *Opopanax* is obtained by means of incisions made at the bottom of the stalk of the plant, from whence the juice gradually exudes; and by undergoing spontaneous concretion, assumes the appearance under which we have it imported from Turkey and the East Indies. It readily mingles with water, by triture, into a milky liquor, which on standing deposits a portion of resinous matter, and becomes yellowish: to rectified spirit it yields a gold-coloured tincture, which tastes and smells strongly of *opopanax*. Water distilled from it is impregna-

ted with its smell, but no essential oil is obtained on committing moderate quantities to the operation." See *PASTANACA*, of which *opopanax* is a species.

OPORTO, or *PORTO*; a rich, handsome, and considerable town of Portugal, in the province of Entre Douro and Minho, with a bishop's see. It is a place of great importance, and by nature almost impregnable. It is noted for its strong wines; and a large quantity is from thence exported into Britain, whence all red wines that come from Spain or Portugal are called *port-wines*. It is seated on the declivity of a mountain near the river Duero, which forms an excellent harbour. W. Long. 8. 1. N. Lat. 41. 6.

OPOSSUM, in zoology. See *DIDELPHIS*.

OPPENHEIM, a town of Germany, in the lower palatinate of the Rhine, and capital of a bailiwick of the same name; seated on the declivity of a hill near the Rhine. E. Long. 8. 20. N. Lat. 49. 48.

OPPIANUS, a poet and grammarian of Anazarba in Cilicia, in the second century. He composed a poem of hunting, and another of fishing, for which Antoninus Caracalla gave him as many golden crowns as there were verses in his poems; they were hence called *Oppian's golden verses*. He died in the 30th year of his age.

OPILATION, in medicine, the act of obstructing or stopping up the passage of the body, by redundant or peccant humours. This word is chiefly used for obstructions in the lower belly.

OPTATIVE MOOD, in grammar, that which serves to express an ardent desire or wish for something.

In most languages, except the Greek, the optative is only expressed by prefixing to the subjunctive an adverb of wishing; as *utinam*, in Latin; *plut à Dieu*, in French; and *would to God*, in English.

OPTIC ANGLE, the angle which the optic axes of both eyes make with one another, as they tend to meet at some distance before the eyes.

OPTIC AXIS, the axis of the eye, or a line going through the middle of the pupil and the centre of the eye.

Oporto
||
Optic.

O P T I C S,

THAT science which treats of the element of light, and the various phenomena of vision.

HISTORY.

§ 1. Discoveries concerning the Light.

THE element of light has occupied much of the attention of thinking men ever since the phenomena of nature have been the objects of rational investigation. The discoveries that have from time to time been made concerning it, are so fully inserted under the article *LIGHT*, that there is little room for any further addition here. The nature of that subtle element is indeed very little known as yet, notwithstanding all the endeavours of philosophers; and whatever side is taken with regard to it, whether we suppose it to consist of an infinity of small particles propagated by a repulsive power from the luminous body, or whether we suppose it to consist in the vibrations of a subtle fluid, there are prodigious difficulties, almost, if not totally insuperable, which will attend the explanation

of its phenomena. In many parts of this work the identity of light and of the electric fluid is asserted: this, however, doth not in the least interfere with the phenomena of optics; all of which are guided by the same invariable laws, whether we suppose light to be a vibration of that fluid, or any thing else. We shall therefore proceed to,

§ 2. Discoveries concerning the Refraction of Light.

WE find that the ancients, though they made very few optical experiments, nevertheless knew, that when light passed through mediums of different densities, it did not move forward in a straight line, but was bent, or *refracted*, out of its course. This was probably suggested to them by the appearance of a straight stick partly immersed in water: and we find many questions concerning this and other optical appearances in Aristotle; to which, however, his answers are insignificant. Archimedes is even said to have written a treatise concerning the appearance of a ring or circle under water, and therefore could not have been ignorant

Refraction
known to
the an-
cients;

rant of the common phenomena of refraction. But the ancients were not only acquainted with these more ordinary appearances of refraction, but knew also the production of colours by refracted light. Seneca says, that if the light of the sun shines through an angular piece of glass, it will show all the colours of the rainbow. These colours, however, he says, are false, such as are seen in a pigeon's neck when it changes its position; and of the same nature, he says, is a speculum, which, without having any colour of its own, assumes that of any other body. It appears also, that the ancients were not unacquainted with the magnifying power of glass globes filled with water, though they do not seem to have known any thing of the reason of this power; and the ancient engravers are supposed to have made use of a glass globe filled with water to magnify their figures, and thereby to work to more advantage. That the power of transparent bodies of a spherical form in magnifying or burning was not wholly unknown to the ancients, is further probable from certain gems preserved in the cabinets of the curious, which are supposed to have belonged to the Druids. They are made of rock-crystal of various forms, amongst which are found some that are lenticular and others that are spherical: and though they are not sufficiently wrought to perform their office as well as they might have done if they had been more judiciously executed, yet it is hardly possible that their effect, in magnifying at least, could have escaped the notice of those who had often occasion to handle them; if indeed, in the spherical or lenticular form, they were not solely intended for the purposes of burning. One of these, of the spherical kind, of about an inch and an half diameter, is preserved among the fossils given to the university of Cambridge by Dr Woodward.

3
And the
magnifying
power of
glass globes.

4
Refraction
first treated
scientifically
by Ptolemy.

The first treatise of any note written on the subject of optics, was by the celebrated astronomer Claudius Ptolemæus, who lived about the middle of the second century. The treatise is lost; but from the accounts of others we find that he treated of astronomical refractions. Though refraction in general had been observed very early, it is possible that it might not have occurred to any philosopher much before his time, that the light of the sun, moon, and stars, must undergo a similar refraction in consequence of falling obliquely upon the gross atmosphere that surrounds the earth; and that they must, by that means, be turned out of their rectilinear course, so as to cause those luminaries to appear higher in the heavens than they would otherwise do. The first astronomers were not aware that the intervals between stars appear less near the horizon than near the meridian; and, on this account, they must have been much embarrassed in their observations. But it is evident that Ptolemy was aware of this circumstance, by the caution that he gives to allow something for it, upon every recourse to ancient observations.

5
His hypothesis
concerning the
horizontal
sun and
moon.

This philosopher also advances a very sensible hypothesis to account for the remarkably greater apparent size of the sun and moon when seen near the horizon. The mind, he says, judges of the size of objects by means of a pre-conceived idea of their distance from us: and this distance is fancied to be greater when a number of objects are interposed between the eye and the body we are viewing; which is the case when we

N^o 246.

see the heavenly bodies near the horizon. In his Almagest, however, he ascribes this appearance to a refraction of the rays by vapours, which actually enlarge the angle under which the luminaries appear; just as the angle is enlarged by which an object is seen from under water.

In the 12th century, the nature of refraction was largely considered by Alhazen an Arabian writer; in so much that, having made experiments upon it at the common surface between air and water, air and glass, water and glass or crystal; and, being prepossessed with the ancient opinion of crystalline orbs in the regions above the atmosphere, he even suspected a refraction there also, and fancied he could prove it by astronomical observations. This author deduces from hence several properties of atmospherical refraction, as that it increases the altitudes of all objects in the heavens; and he first advanced, that the stars are sometimes seen above the horizon by means of refraction, when they are really below it. This observation was confirmed by Vitellio, B. Waltherus, and especially by the excellent observations of Tycho Brahe. Alhazen observed, that refraction contracts the vertical diameters and distances of the heavenly bodies, and that it is the cause of the twinkling of the stars. But we do not find that either he, or his follower Vitellio, knew any of its just quantity. Indeed it is too small to be determined except by very accurate instruments, and therefore we hear little more of it till about the year 1500; at which time great attention was paid to it by Bernard Walther, Mæstlin, and others, but chiefly by Tycho Brahe.

6
Discoveries
of Alhazen.

Alhazen supposed that the refraction of the atmosphere did not depend upon the vapours in it, as was probably the opinion of philosophers before his time, but on the different transparency; by which, as Montucla conjectures, he meant the density of the gross air contiguous to the earth, and the ether or subtile air that lies beyond it. In examining the effects of refraction, he endeavours to prove that it is so far from being the cause of the heavenly bodies appearing larger near the horizon, that it would make them appear less; two stars, he says, appearing nearer together in the horizon, than near the meridian. This phenomenon he ranks among optical deceptions. We judge of distance, he says, by comparing the angle under which objects appear, with their supposed distance; so that if these angles be nearly equal, and the distance of one object be conceived greater than that of the other, it will be imagined to be larger. And the sky near the horizon, he says, is always imagined to be further from us than any other part of the concave surface. Roger Bacon ascribes this account of the horizontal moon to Ptolemy; and as such it is examined, and objected to by B. Porta.

In the writings of this Bacon, whose genius perhaps equalled that of his great namesake Lord Verulam, we find the first distinct account of the magnifying power of glasses; and it is not improbable, that what he wrote upon this subject gave rise to that most useful invention of spectacles. For he says, that if an object be applied close to the base of the larger segment of a sphere of glass, it will appear magnified. He also treats of the appearance of an object through a globe, and says that he was the first who observed the refraction of rays into it.

⁷
Of Vitellio. In 1270, Vitellio, a native of Poland, published a treatise of optics, containing all that was valuable in Alhazen, and digested in a much more intelligible and methodical manner. He observes, that light is always lost by refraction, in consequence of which the objects seen by refracted light always appear less luminous; but he does not pretend to estimate the quantity of this loss. He reduced into a table the result of his experiments on the refractive powers of air, water, and glass, corresponding to different angles of incidence. In his account of the horizontal moon he agrees exactly with Alhazen; observing, that in the horizon she seems to touch the earth, and appears much more distant from us than in the zenith, on account of the intermediate space containing a greater variety of objects upon the visible surface of the earth. He ascribes the twinkling of the stars to the motion of the air in which the light is refracted; and to illustrate this hypothesis, he observes, that they twinkle still more when viewed in water put in motion. He also shows, that refraction is necessary as well as reflection, to form the rainbow; because the body which the rays fall upon is a transparent substance, at the surface of which one part of the light is always reflected and another refracted. But he seems to consider refraction as serving only to condense the light, and thereby enabling it to make a stronger impression upon the eye. This writer also makes some ingenious attempts to explain refraction, or to ascertain the law of it. He also considers the foci of glass spheres, and the apparent size of objects seen through them; though upon these subjects he is not at all exact. It is sufficient indeed to show the state of knowledge, or rather of ignorance, at that time, to observe, that both Vitellio, and his master Alhazen, endeavour to account for objects appearing larger when they are seen under water by the circular figure of its surface; since, being fluid, it conforms to the figure of the earth.

⁸
Of Roger Bacon.

Contemporary with Vitellio was Roger Bacon, a man of very extensive genius, and who wrote upon almost every branch of science; yet in this branch he does not seem to have made any considerable advances beyond what Alhazen had done before him. Even some of the wildest and most absurd of the opinions of the ancients have had the sanction of his authority. He does not hesitate to assent to an opinion adopted by many of the ancients, and indeed by most philosophers till his time, that visual rays proceed from the eye; giving this reason for it, that every thing in nature is qualified to discharge its proper functions by its own powers, in the same manner as the sun and other celestial bodies. In his *Specula Mathematica*, he added some observations on the refraction of the light of the stars; the apparent size of objects; the extraordinary size of the sun and moon in the horizon: but in all this he is not very exact, and advances but little. In his *Opus Majus* he demonstrates, that if a transparent body interposed between the eye and an object, be convex towards the eye, the object will appear magnified. This observation, however, he certainly had from Alhazen; the only difference between them is, that Bacon prefers the smaller segment of a sphere, and Alhazen the larger, in which the latter certainly was right.

From this time, to that of the revival of learning in
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Europe, we have no farther treatise on the subject of refraction, or indeed on any other part of optics. One of the first who distinguished himself in this way was Maurolycus, teacher of mathematics at Messina. In a treatise, *De Lumine et Umbra*, published in 1575, he demonstrates that the crystalline humour of the eye is a lens that collects the rays of light issuing from the objects, and throws them upon the retina where is the focus of each pencil. From this principle he discovered the reason why some people were short-sighted and others long-sighted; and why the former are relieved by concave, and the others by convex, glasses.

About the same time that Maurolycus made such advances towards the discovery of the nature of vision, ⁹ Joannes Baptista Porta of Naples discovered the *camera obscura*, which throws still more light on the same subject. His house was constantly resorted to by all the ingenious persons at Naples, whom he formed into what he called an *academy of secrets*; each member being obliged to contribute something that was not generally known, and might be useful. By this means he was furnished with materials for his *Magia Naturalis*, which contains his account of the *camera obscura*, and the first edition of which was published, as he informs us, when he was not quite 15 years old. He also gave the first hint of the magic lantern; which Kircher afterwards followed and improved. His experiments with the *camera obscura* convinced him, that vision is performed by the intromission of something into the eye, and not by visual rays proceeding from the eye, as had been formerly imagined; and he was the first who fully satisfied himself and others upon this subject. Indeed the resemblance between experiments with the *camera obscura* and the manner in which vision is performed in the eye, was too striking to escape the observation of a less ingenious person. But when he says that the eye is a *camera obscura*, and the pupil the hole in the window-shutter, he was so far mistaken as to suppose that it was the crystalline humour that corresponds to the wall which receives the images; nor was it discovered till the year 1604, that this office is performed by the retina. He makes a variety of just observations concerning vision; and particularly explains several cases in which we imagine things to be without the eye, when the appearances are occasioned by some affection of the eye itself, or some motion within the eye. He observes also, that, in certain circumstances, vision will be assisted by convex or concave glasses; and he seems also to have made some small advances towards the discovery of telescopes. He takes notice, that a round and flat surface plunged into water, will appear hollow as well as magnified to an eye perpendicularly over it; and he very well explains by a figure the manner in which it is done.

All this time, however, the great problem concerning the measuring of refractions had remained unsolved. Alhazen and Vitellio, indeed, had attempted it; but failed, by attempting to measure the angle itself instead of its sine. At last it was discovered by Snellius, professor of mathematics at Leyden. This philosopher, however, did not perfectly understand his own discovery, nor did he live to publish any account of it himself. It was afterwards explained by professor Hortensius both publicly and privately before
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⁹
Of Maurolycus.

¹⁰
Discoveries of B. Porta.

¹¹

The law of refraction discovered.

fore it appeared in the writings of Descartes, who published it under a different form, without making any acknowledgment of his obligations to Snellius, whose papers Huygens assures us, from his own knowledge, Descartes had seen. Before this time Kepler had published a New Table of refracted Angles, determined by his own experiments for every degree of incidence. Kircher had done the same, and attempted a rational or physical theory of refraction, on principle, and on a mode of investigation, which, if conducted with precision, would have led him to the law assumed or discovered by Snellius.

¹²
Opinions
of Descartes
and Leib-
nitz on this
subject.

Descartes undertook to explain the cause of refraction by the resolution of forces, on the principles of mechanics. In consequence of this, he was obliged to suppose that light passes with more ease through a dense medium, than through a rare one. The truth of this explanation was first questioned by M. Fermat, counsellor to the parliament of Thoulouse, and an able mathematician. He asserted, contrary to the opinion of Descartes, that light suffers more resistance in water than air, and more in glass than in water; and he maintained, that the resistance of different mediums with respect to light is in proportion to their densities. M. Leibnitz adopted the same general idea; and these gentlemen argued upon the subject in the following manner.

Nature, say they, accomplishes her ends by the shortest methods. Light therefore ought to pass from one point to another, either by the shortest road, or that in which the least time is required. But it is plain that the line in which light passes, when it falls obliquely upon a denser medium, is not the most direct or the shortest; so that it must be that in which the least time is spent. And whereas it is demonstrable, that light falling obliquely upon a denser medium (in order to take up the least time possible in passing from a point in one medium to a point in the other) must be refracted in such a manner, that the sines of the angles of incidence and refraction must be to one another, as the different facilities with which light is transmitted in those mediums; it follows, that since light approaches the perpendicular when it passes obliquely from air into water, so that the sine of the angle of refraction is less than that of the angle of incidence, the facility with which water suffers light to pass through it is less than that of the air; so that light meets with more resistance in water than air.

¹³
Discoveries
concerning
the refraction
of different
substances.

Arguments of this kind could not give satisfaction; and a little time showed the fallacy of the hypothesis. At a meeting of the Royal Society, Aug. 31. 1664. an experiment for measuring the refraction of common water was made with a new instrument which they had prepared for that purpose; and, the angle of incidence being 40 degrees, that of refraction was found to be 30. About this time also we find the first mention of mediums not refracting the light in an exact proportion to their densities. For Mr Boyle, in a letter to Mr Oldenburgh, dated Nov. 3. 1664, observes, that in spirit-of-wine, the proportion of the sines of the angles of incidence to the sines of the angles of refraction was nearly the same as 4 to 3; and that, as spirit-of-wine occasions a greater refraction than common water, so oil of turpentine, which is lighter than spirit-of-wine, produces not only a greater refraction than common water, but a much greater

than salt water. And at a meeting held Nov. 9. the same year, Dr Hooke (who had been ordered to prosecute the experiment) brought in an account of one that he had made with pure and clear salad oil, which was found to have produced a much greater refraction than any liquor which he had then tried; the angle of refraction that answered to an angle of incidence of 30° being found no less than $40^\circ 30'$, and the angle of refraction that answered to an angle of incidence of 20° being $29^\circ 47'$.—M. de la Hire also made several experiments to ascertain the refractive power of oil with respect to that of water and air, and found the sine of the angle of incidence to that of refraction to be as 60 to 42; which, he observes, is a little nearer to that of glass than to that of water, though oil is much lighter than water, and glass much heavier.

The members of the Royal Society finding that the refraction of salt water exceeded that of fresh, pursued the experiment farther with solutions of vitriol, saltpetre, and alum, in water; when they found the refraction of the solution of vitriol and saltpetre a little more, but that of alum a little less, than common water.

Dr Hooke made an experiment before the Royal Society, Feb. 11. 1663, which clearly proves that ice refracts the light less than water; which he took to be a good argument that the lightness of ice, which causes it to swim in water, is not caused only by the small bubbles which are visible in it, but that it arises from the uniform constitution or general texture of the whole mass. M. de la Hire also took a good deal of pains to determine whether, as was then the common opinion, the refractive power of ice and water were the same; and he found, as Dr Hooke had done before, that ice refracts less than water.

By a most accurate and elaborate experiment made in the year 1698, in which a ray of light was transmitted through a Torricellian vacuum, Mr Lowthorp found, that the refractive power of air is to that of water as 36 to 34,400. He concludes his account of the experiment with observing, that the refractive power of bodies is not proportioned to the density, at least not to the gravity, of the refracting medium. For the refractive power of glass to that of water is as 55 to 34, whereas its gravity is as 87 to 34; that is, the squares of their refractive powers are very nearly as their respective gravities. And there are some fluids, which, though they are lighter than water, yet have a greater power of refraction. Thus the refractive power of spirit-of-wine, according to Dr Hooke's experiment, is to that of water as 36 to 33, and its gravity reciprocally as 33 to 36, or $36\frac{1}{2}$. But the refractive powers of air and water seem to observe the simple proportion of their gravities directly. And if this should be confirmed by succeeding experiments, it is probable, he says, that the refractive powers of the atmosphere are everywhere, and at all heights above the earth, proportioned to its density and expansion: and then it would be no difficult matter to trace the light through it, so as to terminate the shadow of the earth; and, together with proper expedients for measuring the quantity of light illuminating an opaque body, to examine at what distances the moon must be from the earth to suffer eclipses of the observed durations.

Cassini the younger happened to be present when Mr Lowthorp made the above-mentioned experiment before the Royal Society; and upon his return home, having made a report of it to the members of the Royal Academy of Sciences, those gentlemen endeavoured to repeat the experiment in 1700; but they did not succeed.—For, as they said, beams of light passed through the vacuum without suffering any refraction. The Royal Society being informed of this, were desirous that it might be put past dispute, by repeated and well-attested trials; and ordered Mr Hawksbee to make an instrument for the purpose, by the direction of Dr Halley. It consisted of a strong brass prism, two sides of which had sockets to receive two plane glasses, whereby the air in the prism might either be exhausted or condensed. The prism had also a mercurial gage fixed to it, to discover the density of the contained air; and was contrived to turn upon its axis, in order to make the refractions equal on each side when it was fixed to the end of a telescope. The refracting angle was near 64° ; and the length of the telescope was about 10 feet, having a fine hair in its focus. The event of this accurate experiment was as follows:

Having chosen a proper and very distinct erect object, whose distance was 2588 feet, June 15. O. S. 1708, in the morning, the barometer being then at $29.7\frac{1}{2}$, and the thermometer at 60, they first exhausted the prism, and then applying it to the telescope, the horizontal hair in the focus covered a mark on the object distinctly seen through the vacuum, the two glasses being equally inclined to the visual ray. Then admitting the air into the prism, the object was seen to rise above the hair gradually as the air entered, and in the end the hair was observed to hide a mark $10\frac{1}{4}$ inches below the former mark. This they often repeated, and with the same success.

After this they applied the condensing engine to the prism; and having forced in another atmosphere, so that the density of the included air was double to that of the outward, they again placed it before the telescope, and, letting out the air, the object which before seemed to rise, appeared gradually to descend, and the hair at length rested on an object higher than before by the same interval of $10\frac{1}{4}$ inches. This experiment they likewise frequently repeated without any variation in the event.

They then forced in another atmosphere; and upon discharging the condensed air, the object was seen near 21 inches lower than before.

Now the radius in this case being 2588 feet, $10\frac{1}{4}$ inches will subtend an angle of one minute and 8 seconds, and the angle of incidence of the visual ray being 32° (because the angle of the glass planes was 64°), it follows from the known laws of refraction, that as the sine of 39° is to that of 31° , $59'$, $26''$ differing from 32° by $34''$ the half of $1'$, $8''$; so is the sine of any other incidence, to the sine of its angle of refraction; and so is radius, or 1000000, to 999736; which, therefore, is the proportion between the sine of incidence in *vacuo* and the sine of refraction from thence into common air.

It appears, by these experiments, that the refractive power of the air is proportionable to its density. And since the density of the atmosphere is as its

weight directly, and its heat inversely, the ratio of its density, at any given time, may be had by comparing the heights of the barometer and thermometer; and thence he concludes that this will also be the ratio of the refraction of the air. But Dr Smith observes, that, before we can depend upon the accuracy of this conclusion, we ought to examine whether heat and cold alone may not alter the refractive power of air, while its density continues the same. This, he says, may be tried, by heating the condensed or rarefied air, shut up in the prism, just before it is fixed to the telescope, and by observing whether the hair in its focus will continue to cover the same mark all the while that the air is cooling.

The French academicians, being informed of the result of the above-mentioned experiment, employed M. Delisle the younger to repeat their former experiment with more care; and he presently found, that their operators had never made any vacuum at all, there being chinks in their instrument, through which the air had insinuated itself. He therefore annexed a gage to his instrument, by which means he was sure of his vacuum; and then the result of the experiment was the same with that in England. The refraction was always in proportion to the density of the air, excepting when the mercury was very low, and consequently the air very rare; in which case the whole quantity being very small, he could not perceive much difference in them. Comparing, however, the refractive power of the atmosphere, observed at Paris, with the result of his experiment, he found, that the best vacuum he could make was far short of that of the etherial regions above the atmosphere.

Dr Hooke first suggested the thought of making allowance for the effect of the refraction of light, in passing from the higher and rarer, to the lower and denser regions of the atmosphere, in the computed height of mountains. To this he ascribes the different opinions of authors concerning the height of several very high hills. He could not account for the appearance of the Peak of Teneriff, and several very high mountains, at so great a distance as that at which they are actually seen, but upon the supposition of the curvature of the visual ray, that is made by its passing obliquely through a medium of such different density, from the top of them to the eye, very far distant in the horizon. All calculations of the height of mountains that are made upon the supposition that the rays of light come from the tops of them, to our eyes, in straight lines, must, he says, be very erroneous.

Dr Hooke gives a very good account of the twinkling of the stars; ascribing it to the irregular and unequal refraction of the rays of light, which is also the reason why the limbs of the sun, moon, and planets appear to wave or dance. And that there is such an unequal distribution of the parts of the atmosphere, he says, is manifest from the different degrees of heat and cold in the air. This, he says, will be evident by looking upon distant objects, over a piece of hot glass, which cannot be supposed to throw out any kind of exhalation from itself, as well as through ascending steams of water.

About this time Grimaldi first observed that the coloured image of the sun refracted through a prism is

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15
Colours
discovered
to arise
from refraction.

16
Different
refrangibility
of the
rays of
light discovered
by
Sir Isaac
Newton.

always oblong, and that colours proceed from refraction.—The way in which he first discovered this was by Vitellio's experiment above-mentioned, in which a piece of white paper placed at the bottom of a glass vessel filled with water, and exposed to the light of the sun, appears coloured. However, he observed, that in case the two surfaces of the refracting medium were exactly parallel to each other, no colours were produced. But of the true cause of those colours, viz. the different refrangibility of the rays of light, he had not the least suspicion. This discovery was reserved for Sir Isaac Newton, and which occurred to him in the year 1666. At that time he was busied in grinding optic glasses, and procured a triangular glass prism to satisfy himself concerning the phenomena of colours. While he amused himself with this, the oblong figure of the coloured spectrum first struck him. He was surprised at the great disproportion betwixt its length and breadth; the former being about five times the measure of the latter. He could hardly think that any difference in the thickness of the glass, or in the composition of it, could have such an influence on the light. However, without concluding any thing *a priori*, he proceeded to examine the effects of these circumstances, and particularly tried what would be the consequence of transmitting the light through parts of the glass that were of different thicknesses, or through holes in the window-shutter of different sizes; or by setting the prism on the outside of the shutter, that the light might pass through it, and be refracted before it was terminated by the hole.

He then suspected that these colours might arise from the light being dilated by some unevenness in the glass, or some other accidental irregularity; and to try this, he took another prism, like the former, and placed it in such a manner, as that the light, passing through them both, might be refracted contrarywise, and so be returned by the latter into the same course from which it had been diverted by the former. In this manner he thought that the regular effects of the first prism would be destroyed by the second; but that the irregular ones would be augmented by the multiplicity of refractions. The event was, that the light, which by the first prism was diffused into an oblong form, was by the second reduced into a circular one, with as much regularity as if it had not passed through either of them.

At last, after various experiments and conjectures, he hit upon what he calls the *experimentum crucis*, and which completed this great discovery. He took two boards, and placed one of them close behind the prism at the windows, so that the light might pass through a small hole made in it for the purpose, and fall on the other board, which he placed at the distance of about 12 feet; having first made a small hole in it also, for some of that incident light to pass through. He then placed another prism behind the second board, so that the light which was transmitted through both the boards might pass through that also, and be again refracted before it arrived at the wall. This being done, he took the first prism in his hand, and turned it about its axis, so much as to make the several parts of the image, cast on the second board, successively to pass through the hole in it, that he

might observe to what places on the wall the second prism would refract them; and he saw, by the change of those places, that the light tending to that end of the image towards which the refraction of the first prism was made, did, in the second prism, suffer a refraction considerably greater than the light which tended to the other end. The true cause, therefore, of the length of the image was discovered to be no other, than that light is not similar, or homogeneous; but that it consists of rays, some of which are more refrangible than others: so that, without any difference in their incidence on the same medium, some of them shall be more refracted than others; and therefore, that, according to their particular degrees of refrangibility, they will be transmitted through the prism to different parts of the opposite wall.

Since it appears from these experiments that different rays of light have different degrees of refrangibility, it necessarily follows, that the rules laid down by preceding philosophers concerning the refractive power of water, glass, &c. must be limited to the middle kind of rays. Sir Isaac, however, proves that the sine of the incidence of every kind of light, considered apart, is to its sine of refraction in a given ratio. This he deduces, both by experiment, and also geometrically, from the supposition that bodies refract the light by acting upon its rays in lines perpendicular to their surfaces.

The most important discovery with regard to refraction since the time of Sir Isaac Newton is that of Mr Dollond, who found out a method of curing the faults of refracting telescopes arising from the different refrangibility of the rays, and which had been generally thought impossible to be removed.—Notwithstanding the great discovery of Sir Isaac Newton concerning the different refrangibility of the rays of light, he had no idea but that they were all affected in the same proportion by every medium, so that the refrangibility of the extreme rays might be determined if that of the mean ones was given. From this it would follow, as Mr Dollond observes, that equal and contrary refractions must not only destroy each other, but that the divergency of the colours from one refraction would likewise be corrected by the other, and that there could be no possibility of producing any such thing as refraction which would not be affected by the different refrangibility of light; or, in other words, that however a ray of light might be refracted backwards and forwards by different mediums, as water, glass, &c. provided it was so done, that the emergent ray should be parallel to the incident one, it would ever after be white; and consequently, if it should come out inclined to the incident, it would diverge, and ever after be coloured; and from this it was natural to infer, that all spherical object-glasses of telescopes must be equally affected by the different refrangibility of light, in proportion to their apertures, of whatever materials they may be formed.

For this reason, Sir Isaac Newton, and all other philosophers and opticians, had despaired of bringing refracting telescopes to any great degree of perfection, without making them of an immoderate and very inconvenient length. They therefore applied themselves chiefly to the improvement of the reflecting telescope; and the business of refraction was dropped till

17
Mr Dollond's discovery of the method of correcting the faults in refracting telescopes.

about the year 1747, when M. Euler, improving upon a hint of Sir Isaac Newton's, formed a scheme of making object-glasses of two materials, of different refractive powers; hoping, that by this difference, the refractions would balance one another, and thereby prevent the dispersion of the rays that is occasioned by the difference of refrangibility. These object-glasses were composed of two lenses of glass with water between them. This memoir of M. Euler excited the attention of Mr Dollond. He carefully went over all M. Euler's calculations, substituting for his hypothetical laws of refraction those which had been actually ascertained by the experiments of Newton; and found, that, after this necessary substitution, it followed from M. Euler's own principles, that there could be no union of the foci of all kinds of colours, but in a lens infinitely large.

M. Euler did not mean to controvert the experiments of Newton: but he said, that they were not contrary to his hypothesis, but in so small a degree as might be neglected; and asserted, that, if they were admitted in all their extent, it would be impossible to correct the difference of refrangibility occasioned by the transmission of the rays from one medium into another of different density; a correction which he thought was very possible, since he supposed it to be actually effected in the structure of the eye, which in his opinion was made to consist of different mediums for that very purpose. To this kind of reasoning Mr Dollond made no reply, but by appealing to the experiments of Newton, and the great circumspection with which it was known that he conducted all his inquiries.

In this state of the controversy, the friends of M. Clairaut engaged him to attend to it; and it appeared to him, that, since the experiments of Newton cited by Mr Dollond could not be questioned, the speculations of M. Euler were more ingenious than useful.

The same paper of M. Euler was also particularly noticed by M. Klingenshierna of Sweden, who gave a considerable degree of attention to the subject, and discovered, that, from Newton's own principles, the result of the 8th experiment of the second book of his Optics could not answer his description of it.

He found, he says, that when light goes out of air through several contiguous refracting mediums, as through water and glass, and thence goes out again into air, whether the refracting surfaces be parallel or inclined to one another, that light, as often as by contrary refractions it is so corrected as to emerge in lines parallel to those in which it was incident, continues ever after to be white; but if the emergent rays be inclined to the incident, the whiteness of the emerging light will, by degrees, in passing on from the place of emergence, become tinged at its edges with colours. This he tried by refracting light with prisms of glass, placed within a prismatic vessel of water.

By theorems deduced from this experiment he infers, that the refractions of the rays of every sort, made out of any medium into air, are known by having the refraction of the rays of any one sort; and also that the refraction out of one medium into another is found as often as we have the refractions out of them both into any third medium.

On the contrary, the Swedish philosopher observes, that, in this experiment, the rays of light, after passing through the water and the glass, though they come out parallel to the incident rays, will be coloured; but that the smaller the glass prism is, the nearer will the result of it approach to Newton's description.

This paper of M. Klingenshierna being communicated to Mr Dollond by M. Mallet, made him entertain doubts concerning Newton's report, and determined him to have recourse to experiment.

He therefore cemented together two plates of parallel glass at their edges, so as to form a prismatic vessel, when stopped at the ends or bases; and the edge being turned downwards, he placed in it a glass prism, with one of its edges upwards, and filled up the vacancy with clear water; so that the refraction of the prism was contrived to be contrary to that of the water, in order that a ray of light, transmitted through both these refracting mediums, might be affected by the difference only between the two refractions. As he found the water to refract more or less than the glass prism, he diminished or increased the angle between the glass plates, till he found the two contrary refractions to be equal; which he discovered by viewing an object thro' this double prism. For when it appeared neither raised nor depressed, he was satisfied that the refractions were equal, and that the emergent rays were parallel to the incident.

Now, according to the prevailing opinion, he observes, the object should have appeared through this double prism in its natural colour; for if the difference of refrangibility had been in all respects equal in the two equal refractions, they would have rectified each other. But this experiment fully proved the fallacy of the received opinion, by showing the divergency of the light by the glass prism to be almost double of that by the water; for the image of the object, though not at all refracted, was yet as much infected with prismatic colours, as if it had been seen through a glass wedge only, whose refracting angle was near 30 degrees.

This experiment is the very same with that of Sir Isaac Newton's above-mentioned, notwithstanding the result was so remarkably different; but Mr Dollond assures us, that he used all possible precaution and care in his process; and he kept his apparatus by him, that he might evince the truth of what he wrote, whenever he should be properly required to do it.

He plainly saw, however, that if the refracting angle of the water vessel could have admitted of a sufficient increase, the divergency of the coloured rays would have been greatly diminished, or entirely rectified; and that there would have been a very great refraction without colour, as he had already produced a great discolouring without refraction: but the incon- veniency of so large an angle as that of the prismatic vessel must have been, to bring the light to an equal divergency with that of the glass prism whose angle was about 60 degrees, made it necessary to try some experiments of the same kind with smaller angles.

Accordingly, he got a wedge of plate glass, the angle of which was only nine degrees; and using it in the same circumstances, he increased the angle of the

water

water wedge, in which it was placed, till the divergency of the light by the water was equal to that by the glass; that is, till the image of the object, though considerably refracted by the excess of the refraction of the water, appeared nevertheless quite free from any colours proceeding from the different refrangibility of the light; and, as near as he could then measure, the refraction by the water was about $\frac{1}{2}$ of that by the glass. He acknowledges, indeed, that he was not very exact in taking the measures, because his business was not at that time to determine the exact proportions, so much as to show that the divergency of the colours, by different substances, was by no means in proportion to the refractions, and that there was a possibility of refraction without any divergency of the light at all.

As these experiments clearly proved, that different substances made the light to diverge very differently in proportion to their general refractive power, Mr Dollond began to suspect that such variety might possibly be found in different kinds of glass, especially as experience had already shown that some of the kinds made much better object-glasses in the usual way than others; and as no satisfactory cause had been assigned for such difference, he thought there was great reason to presume that it might be owing to the different divergency of the light in the same refractions.

His next business, therefore, was to grind wedges of different kinds of glass, and apply them together; so that the refractions might be made in contrary directions, in order to discover, as in the above-mentioned experiments, whether the refraction and the divergency of the colours would vanish together. But a considerable time elapsed before he could set about that work: for though he was determined to try it at his leisure, for satisfying his own curiosity, he did not expect to meet with a difference sufficient to give room for any great improvement of telescopes, so that it was not till the latter end of the year 1757 that he undertook it; but his first trials convinced him that the business deserved his utmost attention and application.

He discovered a difference far beyond his hopes in the refractive qualities of different kinds of glass, with respect to the divergency of colours. The yellow or straw-coloured foreign sort, commonly called *Venice glass*; and the *English crown glass*, proved to be very nearly alike in that respect; though, in general, the crown glass seemed to make the light diverge the less of the two. The common English plate-glass made the light diverge more; and the white crystal, or English flint glass, most of all.

It was now his business to examine the particular qualities of every kind of glass that he could come at, not to amuse himself with conjectures about the cause of this difference, but to fix upon two sorts in which it should be the greatest; and he soon found these to be the crown glass and the white flint glass. He therefore ground one wedge of white flint, of about 25 degrees; and another of crown glass, of about 29 degrees: which refracted very nearly alike, but their power of making the colours diverge was very different. He then ground several others of crown glass to different angles, till he got one which was equal,

with respect to the divergency of the light, to that in the white flint-glass: for when they were put together, so as to refract in contrary directions, the refracted light was entirely free from colours. Then measuring the refraction of each wedge with these different angles, he found that of the white glass to be to that of the crown glass nearly as two to three: and this proportion held very nearly in all small angles; so that any two wedges made in this proportion, and applied together, so as to refract in a contrary direction, would refract the light without any dispersion of the rays.

In a letter to M. Klingenshierna, quoted by M. Clairaut, Mr Dollond says, that the sine of incidence in crown glass is to that of its general refraction as 1 to 1.53, and in flint glass as 1 to 1.583.

To apply this knowledge to practice, Mr Dollond went to work upon the object-glasses of telescopes; not doubting but that, upon the same principles on which a refracted colourless ray was produced by prisms, it might be done by lenses also, made of similar materials. And he succeeded, by considering, that, in order to make two spherical glasses that should refract the light in contrary directions, the one must be concave and the other convex; and as the rays are to converge to a real focus, the excess of refraction must evidently be in the convex lens. Also, as the convex glass is to refract the most, it appeared from his experiments, that it must be made of crown glass, and the concave of white flint glass. Farther, as the refractions of spherical glasses are in an inverse ratio of their focal distances, it follows, that the focal distances of the two glasses shall be inversely as the ratios of the refractions of the wedges; for being thus proportioned, every ray of light that passes through this combined glass, at whatever distance it may pass from its axis, will constantly be refracted, by the difference between two contrary refractions, in the proportion required; and therefore the different refrangibility of the light will be entirely removed.

Notwithstanding our author had these clear grounds in theory and experiment to go upon, he found that he had many difficulties to struggle with when he came to reduce them into actual practice; but with great patience and address, he at length got into a ready method of making telescopes upon these new principles.

His principal difficulties arose from the following circumstances. In the first place, the focal distances, as well as the particular surfaces, must be very nicely proportioned to the densities or refracting powers of the glasses, which are very apt to vary in the same sort of glass made at different times. Secondly, The centres of the two glasses must be placed truly in the common axis of the telescope, otherwise the desired effect will be in a great measure destroyed. Add to these, that there are four surfaces to be wrought perfectly spherical; and any person, he says, but moderately practised in optical operations, will allow, that there must be the greatest accuracy throughout the whole work. At length, however, after numerous trials, and a resolute perseverance, he was able to construct refracting telescopes, with such apertures and magnifying powers, under limited lengths, as, in the opinion of the best judges, far exceeded any thing that had been produced

duced before, representing objects with great distinctness, and in their true colours.

It was objected to Mr Dollond's discovery, that the small dispersion of the rays in crown glass is only apparent, owing to the opacity of that kind of glass which does not transmit the fainter coloured rays in a sufficient quantity; but this objection is particularly considered, and answered by M. Beguelin.

As Mr Dollond did not explain the methods which he took in the choice of different spheres proper to destroy the effect of the different refrangibility of the rays of light, and gave no hint that he himself had any rule to direct himself in it; and as the calculation of the dispersion of the rays, in so complicated an affair, is very delicate; M. Clairaut, who had given a good deal of attention to this subject, from the beginning of the controversy, endeavoured to make out a complete theory of it.

Without some assistance of this kind, it is impossible, says this author, to construct telescopes of equal goodness with those of Mr Dollond, except by a servile imitation of his; which, however, on many accounts, would be very unlikely to answer. Besides, Mr Dollond only gave his proportions in general, and pretty near the truth; whereas the greatest possible precision is necessary. Also the best of Mr Dollond's telescopes were far short of the Newtonian ones (A); whereas it might be expected that they should exceed them, if the foci of all the coloured rays could be as perfectly united after refraction through glass, as after reflexion from a mirror; since there is more light lost in the latter case than in the former.

With a view, therefore, to assist the artist, he endeavoured to ascertain the refractive power of different kinds of glass, and also their property of separating the rays of light, by the following exact methods. He made use of two prisms placed close to one another, as Mr Dollond had done: but, instead of looking through them, he placed them in a darkened room; and when the image of the sun, transmitted through them, was perfectly white, he concluded that the different refrangibility of the rays was corrected.

In order to ascertain with more ease the true angles that prisms ought to have to destroy the effect of the difference of refrangibility, he constructed one which had one of its surfaces cylindrical, with several degrees of amplitude. By this means, without changing his prisms, he had the choice of an infinity of angles; among which, by examining the point of the curve surface, which, receiving the solar ray, gave a white image, he could easily find the true one.

He also ascertained the proportion in which different kinds of glass separated the rays of light, by measuring, with proper precautions, the oblong image of the sun, made by transmitting a beam of light through them. In making these experiments, he hit upon an easy method of convincing any person of the greater refractive power of English flint-glass above the common French glass, both with respect to the mean refraction, and the different refrangibility of the co-

lours; for having taken two prisms, of these two kinds of glass, but equal in all other respects, and placed them so that they received, at the same time, two rays of the sun, with the same degree of incidence, he saw, that, of the two images, that which was produced by the English flint-glass was a little higher up on the wall than the other, and longer by more than one half.

M. Clairaut was assisted in these experiments by M. De Tournieres, and the results agreed with Mr Dollond's in general; but whereas Mr Dollond had made the dispersion of the rays in glass and in water to be as five to four (acknowledging, however, that he did not pretend to do it with exactness), these gentlemen, who took more pains, and used more precautions, found it to be as three to two. For the theorems and problems deduced by M. Clairaut from these new principles of optics, with a view to the perfection of telescopes, we must refer the reader to *Mem. Acad. Par.* 1756, 1757.

The labours of M. Clairaut were succeeded by those of M. D'Alembert, which seem to have given the makers of these achromatic telescopes all the aid that calculations can afford them. This excellent mathematician has likewise proposed a variety of new constructions of these telescopes, the advantages and disadvantages of which he distinctly notes; at the same time that he points out several methods of correcting the errors to which they are liable: as by placing the object-glasses, in some cases, at a small distance from one another, and sometimes by using eye-glasses of different refractive powers; which is an expedient that seems not to have occurred to any person before him. He even shows, that telescopes may be made to advantage, consisting of only one object-glass, and an eye-glass of a different refractive power. Some of his constructions have two or more eye-glasses of different kinds of glass. This subject he considered at large in one of the volumes of his *Opuscules Mathematiques*. We have also three memoirs of M. D'Alembert upon this subject, among those of the French Academy; one in the year 1764, another in 1765, and a third in 1767.

At the conclusion of his second memoir he says, that he does not doubt, but, by the different methods he proposes, achromatic telescopes may be made to far greater degrees of perfection than any that have been seen hitherto, and even such as is hardly credible: And though the crown glass, by its greenish colour, may absorb some part of the red or violet rays, which, however, is not found to be the case in fact; that objection cannot be made to the common French glass, which is white, and which on this account he thinks must be preferable to the English crown glass.

Notwithstanding Messrs Clairaut and D'Alembert seemed to have exhausted the business of calculation on the subject of Mr Dollond's telescopes, no use could be made of their labours by foreign artists. For still the telescopes made in England, according to no exact rule,

(A) This assertion of M. Clairaut might be true at the time that it was made, but it is by no means so at present.

rule, as foreigners supposed, were greatly superior to any that could be made elsewhere, though under the immediate direction of those able calculators. For this M. Beguelin assigned several reasons. Among others, he thought that their geometrical theorems were too general, and their calculations too complicated, for the use of workmen. He also thought, that in consequence of neglecting small quantities, which these calculators professedly did, in order to make their algebraical expressions more commodious, their conclusions were not sufficiently exact. But what he thought to be of the most consequence, was the want of an exact method of measuring the refractive and dispersing powers of the different kinds of glass; and for want of this, the greatest precision in calculation was altogether useless.

These considerations induced this gentleman to take another view of this subject; but still he could not reconcile the actual effect of Mr Dollond's telescopes with his own conclusions: so that he imagined, either that he had not the true refraction and dispersion of the two kinds of glass given him; or else, that the aberration which still remained after his calculations, must have been destroyed by some irregularity in the surfaces of the lenses. He finds several errors in the calculations both of M. D'Alembert and Clairaut, and concludes with expressing his design to pursue this subject much farther.

M. Euler, who first gave occasion to this inquiry, which terminated so happily for the advancement of science, being persuaded both by his reasoning and calculations, that Mr Dollond had discovered no new principle in optics, and yet not being able to controvert Mr Short's testimony in favour of the goodness of his telescopes, concluded that this extraordinary effect was owing, in part, to the crown glass not transmitting all the red light, which would otherwise have come to a different focus, and have distorted the image; but principally to his happening to hit on a just curvature of his glass, which he did not doubt would have produced the same effect if his lenses had all been made of the same kind of glass. In another place he imagines that the goodness of Mr Dollond's telescope might be owing to the eye-glass. If my theory, says he, be true, this disagreeable consequence follows, that Mr Dollond's object-glasses cannot be exempt from the dispersion of colours: yet a regard to so respectable a testimony embarrasses me extremely, it being as difficult to question such express authority, as to abandon a theory which appears to me perfectly well founded, and to embrace an opinion, which is as contrary to all the established laws of nature as it is strange and seemingly absurd. He even appeals to experiments made in a darkened room; in which, he says, he is confident that Mr Dollond's object-glasses would appear to have the same defects that others are subject to.

Not doubting, however, but that Mr Dollond, either by chance, or otherwise, had made some considerable improvement in the construction of telescopes, by the combination of glasses, he abandoned his former project, in which he had recourse to different mediums, and confined his attention to the correction of the errors which arise from the curvature of lenses. But while he was proceeding, as he imagined, upon the

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true principles of optics, of which, however, he made but little use, he could not help expressing his surprise that Mr Dollond should have been led to so important a discovery by reasoning in a manner quite contrary to the nature of things. At length, however, M. Euler was convinced of the reality and importance of Mr Dollond's discoveries; and very frankly acknowledges, that he should perhaps never have been brought to assent to it, had not his friend M. Clairaut assured him that the experiments of the English optician might be depended upon. However, the experiments of M. Zeiher of Peterburgh gave him the most complete satisfaction with respect to this new law of refraction.

This gentleman demonstrated, that it is the lead in the composition of glass that gives it this remarkable property, that while the refraction of the mean rays is nearly the same, that of the extremes differs considerably. And, by increasing the quantity of lead in the mixture, he produced a kind of glass, which occasioned a much greater separation of the extreme rays than the flint-glass which Mr Dollond had made use of. By this evidence M. Euler owns that he was compelled to renounce the principle which, before this time, had been considered as incontestible, viz. that the dispersion of the extreme rays depends upon the refraction of the mean: and that the former varies with the quality of the glass, while the latter is not affected by it.

From these new principles M. Euler deduces theorems concerning the combination of the lenses, and, in a manner similar to M. Clairaut and D'Alembert, points out methods of constructing achromatic telescopes.

While he was employed upon this subject, he informs us, that he received a letter from M. Zeiher, dated Peterburgh 30th of January 1764, in which he gives him a particular account of the success of his experiments on the composition of glass; and that, having mixed minium and sand in different proportions, the result of the mean refraction and the dispersion of the rays varied according to the following table.

Proportion of minium to flint.	Mean refraction from air into glass.	Dispersion of the rays in comparison of crown-glass.
I. — 3 : 1	2028 : 1000	4800 : 1000
II. — 2 : 1	1830 : 1000	3550 : 1080
III. — 1 : 1	1787 : 1000	3259 : 1000
IV. — $\frac{1}{2}$: 1	1732 : 1000	2207 : 1000
V. — $\frac{1}{3}$: 1	1724 : 1000	1800 : 1000
VI. — $\frac{1}{4}$: 1	1664 : 1000	1354 : 1000

By this table it is evident, that a greater quantity of lead not only occasions a greater dispersion of the rays, but also considerably increases the mean refraction. The first of these kinds of glass, which contains three times as much minium as flint, will appear very extraordinary; since, hitherto, no transparent substance has been known, whose refractive power exceeded the ratio of two to one, and that the dispersion occasioned by this glass is almost five times as great as that of crown glass, which could not be believed by those who

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Different
composi-
tions of
glass for the
purpose of
correcting
the faults
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ing tele-
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entertained any doubt concerning the same property in flint glass, the effect of which is three times as great as crown glass. One may observe, however, in these kinds of glass, something of a proportion between the mean refraction and the dispersion of rays, which may enable us to reconcile these surprising effects with other principles already known.

Here, however, M. Euler announces to us another discovery of the same M. Zeiher, no less surprising than the former, and which disconcerted all his schemes for reconciling the above-mentioned phenomena. As the six kinds of glass mentioned in the above table were composed of nothing but minium and flint, M. Zeiher happened to think of mixing alkaline salts with them, in order to give the glass a consistence more proper for dioptric uses; when he was much surprised to find this mixture greatly diminished the mean refraction, almost without making any change in the dispersion. After many trials, he at length obtained a kind of glass greatly superior to the flint-glass of Mr Dollond, with respect to the construction of telescopes; since it occasioned three times as great a dispersion of the rays as the common glass, at the same time that the mean refraction was only as 1.61 to 1.

M. Euler also gives particular instructions how to find both the mean and extreme refractive power of different kinds of glass; and particularly advises to make use of prisms with very large refracting angles, not less than 70° .

Notwithstanding it evidently appeared, we may say, to almost all philosophers, that Mr Dollond had made a real discovery of something not comprehended in the optical principles of Sir Isaac Newton, it did not appear so to Mr Murdoch. Upon this occasion, he interposed in the defence, as he imagined, of Sir Isaac Newton; maintaining, that Mr Dollond's positions, which, he says, he knows not by what mishap have been deemed paradoxes in Sir Isaac's theory of light, are really the necessary consequences of it. He also endeavours to show that Sir Isaac might not be mistaken in his account of the experiment above-mentioned. But, admitting all that he advances in this part of his defence, Newton must have made use of a prism with a much smaller refracting angle than, from his own account of his experiments, we have any reason to believe that he ever did make use of.

The fact probably was, that Sir Isaac deceived himself in this case, by attending to what he imagined to be the clear consequence of his other experiments; and though the light he saw was certainly tinged with colours, and he must have seen it to be so, yet he might imagine that this circumstance arose from some imperfection in his prisms, or in the disposition of them, which he did not think it worth his while to examine. It is also observable, that Sir Isaac is not so particular in his description of his prisms, and other parts of his apparatus, in his account of this experiment, as he generally is in other cases; and therefore, probably, wrote his account of it from his memory only. In reality, it is no reflection upon Sir Isaac Newton, who did so much, to say that he was mistaken in this particular case, and that he did not make the discovery that Mr Dollond did; though it be great praise to Mr Dollond, and all those persons who contributed to

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this discovery, that they ventured to call in question the authority of so great a man.

Mr Dollond, however, was not the only optician who had the merit of making this discovery; it had been made and applied to the same purpose by a private gentleman—Mr Chest of Chest-hall. He had observed that prisms of flint glass gave larger spectrums than prisms of water when the mean refraction was the same in both, i. e. when the deviation of the refracted ray from the direction of the incident was the same. He tried prisms of other glass, and found similar differences; and he employed the discovery in the same manner, and made achromatic experiments some time before Dollond. These facts came out in a process raised at the instance of Watkins optician at Charing-cross, as also in a publication by Mr Ramsden optician. There is, however, no evidence that Dollond stole the idea from Mr Chest, or that they had not both claims to the discovery.

Still the best refracting telescopes, constructed on the principles of Mr Dollond, are defective, on account of that colour which, by the aberration of the rays, they give to objects viewed through them, unless the object glass be of small diameter. This defect men of genius and science have laboured to remove, some by one contrivance and some by another. Father Boscovich, to whom every branch of optics is much indebted, has, in his attempts for this purpose, displayed much ingenuity; but the philosopher whose exertions have been crowned with most success, and who has perhaps made the most important discovery in this branch of science since the era of Newton, is Dr Robert Blair regius professor of astronomy in the college of Edinburgh. By a judicious set of experiments ably conducted, he has proved, that the quality of dispersing the rays in a greater degree than crown glass, is not confined to a few mediums, but is possessed by a great variety of fluids, and by some of these in a most extraordinary degree. He has shown, that although the greater refrangibility of the violet rays than of the red rays, when light passes from any medium whatever into a vacuum, may be considered as a law of nature; yet in the passages of light from one medium into another, it depends entirely on the qualities of the mediums which of these rays shall be the most refrangible, or whether there shall be any difference in their refrangibility. In order to correct the aberration arising from difference of refrangibility among the rays of light, he instituted a set of experiments, in the conducting of which he detected a very singular and important quality in the muriatic acid. In all the dispersive mediums hitherto examined, the green rays, which are the mean refrangible in crown glass, were found among the less refrangible; but in the muriatic acid, these same rays were by him found to make a part of the more refrangible. This discovery led to complete success in removing the great defect of optical instruments, viz. that dissipation or aberration of the rays which arise from their unequal refrangibility, and has hitherto rendered it impossible to converge all of them to one point either by single or opposite refractions. A fluid, in which the particles of marine acid and metalline particles hold a due proportion, at the same time that it separates the extreme rays of the

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spectrum

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Discovery
of Dr Robert Blair
for this purpose.

spectrum much more than crown glass, refracts all the orders of the rays in the same proportion that glass does: and hence rays of all colours made to diverge by the refraction of the glass, may either be rendered parallel by a subsequent refraction made in the confine of the glass and this fluid; or, by weakening the refractive density of the fluid, the refraction which takes place in the confine of it and glass may be rendered as regular as reflection, without the least colour whatever. The Doctor has a telescope, not exceeding 15 inches in length, with a compound object glass of this kind, which equals in all respects, if it does not surpass, the best of Dollond's 42 inches long. Of this object glass a figure will be found in the third volume of the Transactions of the Royal Society of Edinburgh; and to that volume we must refer our readers for a full and perspicuous account of the experiments which led to this discovery, as well as of the important purposes to which it may be applied.

20
Of the re-
fraction of
the atmo-
sphere.

We shall conclude the history of the discoveries concerning refraction, with some account of the refractions of the atmosphere.—Tables of this have been calculated by Mr Lambert, with a view to correct the inaccuracies of geometrical observations of the altitudes of mountains. The observations of Mr Lambert, however, go upon the supposition that the refractive power of the atmosphere is invariable: But this is by no means the case; and therefore his rules must be considered as true for the mean state of the air only.

A most remarkable variety in the refractive power of the atmosphere was observed by Dr Nettleton, near Halifax in Yorkshire, which demonstrates how little we can depend upon the calculated heights of mountains, when the observations are made with an instrument, and the refractive power of the air is to be allowed for. Being desirous to learn, by observation, how far the mercury would descend in the barometer at any given elevation (for which there is the best opportunity in that hilly country), he proposed to take the height of some of their highest hills; but when he attempted it, he found his observation so much disturbed by refraction, that he could come to no certainty. Having measured one hill of a considerable height, in a clear day, and observed the mercury at the bottom and at the top, he found, according to that estimation, that about 90 feet or more were required to make the mercury fall $\frac{1}{10}$ th of an inch; but afterwards, repeating the experiment on a cloudy day, when the air was rather gross and hazy, he found the small angles so much increased by refraction as to make the hill much higher than before. He afterwards frequently made observations at his own house, by pointing a quadrant to the tops of some neighbouring hills, and observed that they would appear higher in the morning before sunrise, and also late in the evening, than at noon in a clear day, by several minutes. In one case the elevations of the same hill differed more than 30 minutes. From this he infers, that observations made on very high hills, especially when viewed at a distance, and under small angles, as they generally are, are probably uncertain, and not much to be depended upon.

M. Euler considered with great accuracy the refractive power of the atmosphere, as affected by different

degrees of heat and elasticity; in which he shows, that its refractive power, to a considerable distance from the zenith, is sufficiently near the proportion of the tangent of that distance, and that the law of refraction follows the direct ratio of the height of the barometer, and the inverse ratio of the difference marked by the thermometer; but when stars are in the horizon, the changes are in a ratio somewhat greater than this, more especially on account of the variation in the heat.

The cause of the twinkling of the stars is now generally acknowledged to be the unequal refraction of light, in consequence of inequalities and undulations in the atmosphere.

21
Mr Michell's opinion concerning the twinkling of the stars.

Mr Michell supposes that the arrival of fewer or more rays at one time, especially from the smaller or the more remote fixed stars, may make such an unequal impression upon the eye, as may, at least, have some share in producing this effect; since it may be supposed, that even a single particle of light is sufficient to make a sensible impression upon the organs of sight; so that very few particles arriving at the eye in a second of time, perhaps no more than three or four, may be sufficient to make an object constantly visible. For though the impression may be considered as momentary, yet the perception occasioned by it is of some duration. Hence, he says, it is not improbable that the number of the particles of light which enter the eye in a second of time, even from Sirius himself (the light of which does not exceed that of the smallest visible fixed star, in a greater proportion than that of about 1000 to 1), may not exceed 3000 or 4000, and from stars of the second magnitude they may, therefore, probably not exceed 100. Now the apparent increase and diminution of the light which we observe in the twinkling of the stars, seems to be repeated at not very unequal intervals, perhaps about four or five times in a second. He therefore thought it reasonable to suppose, that the inequalities which will naturally arise from the chance of the rays coming sometimes a little denser, and sometimes a little rarer, in so small a number of them as must fall upon the eye in the fourth or fifth part of a second, may be sufficient to account for this appearance. An addition of two or three particles of light, or perhaps a single one, upon 20, especially if there should be an equal deficiency out of the next 20, would, he supposed, be very sensible, as he thought was probable from the very great difference in the appearance of stars, the light of which does not differ so much as is commonly imagined. The light of the middlemost star in the tail of the Great Bear does not, he thinks, exceed the light of the very small star that is next to it in a greater proportion than that of about 16 or 20 to 1; and M. Bouguer found, that a difference in the light of objects of one part in 66 was sufficiently distinguishable.

It will perhaps, he says, be objected, that the rays coming from Sirius are too numerous to admit of a sufficient inequality arising from the common effect of chance so frequently as would be necessary to produce this effect, whatever might happen with respect to the smaller stars; but he observes, that, till we know what inequality is necessary to produce this effect, we can only guess at it one way or the other.

Since these observations were published, Mr Michell has entertained some suspicion that the unequal den-

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sity of light does not contribute to this effect in so great a degree as he had imagined, especially in consequence of observing that even Venus does sometimes twinkle. This he once observed her to do remarkably when she was about 6 degrees high, though Jupiter, which was then about 16 degrees high, and was sensibly less luminous, did not twinkle at all. If, notwithstanding the great number of rays which, no doubt, come to the eye from such a surface as this planet presents, its appearance be liable to be affected in this manner, it must be owing to such undulations in the atmosphere, as will probably render the effect of every other cause altogether insensible. The conjecture, however, has so much probability in it, that it well deserved to be recited.

²² Mr Muschenbroek suspects, that the twinkling of the stars arises from some affection of the eye, as well as the state of the atmosphere. For he says, that in Holland, when the weather is frosty, and the sky very clear, the stars twinkle most manifestly to the naked eye, though not in telescopes; and since he does not suppose that there is any great exhalation, or dancing of the vapour at that time, he questions whether the vivacity of the light affecting the eye may not be concerned in the phenomenon.

But this philosopher might very easily have satisfied himself with respect to this hypothesis, by looking at the stars near the zenith, when the light traverses but a small part of the atmosphere, and therefore might be expected to affect the eye the most sensibly. For he would not have perceived them to twinkle near so much, as they do near the horizon, when much more of their light is intercepted by the atmosphere.

Some astronomers have lately endeavoured to explain the twinkling of the fixed stars by the extreme minuteness of their apparent diameter; so that they suppose the light of them is intercepted by every mote that floats in the air. But Mr Michell observes, that no object can hide a star from us that is not large enough to exceed the apparent diameter of the star, by the diameter of the pupil of the eye; so that if a star was a mathematical point, the interposing object must still be equal in size to the pupil of the eye: nay, it must be large enough to hide the star from both eyes at the same time.

Besides a variation in the quantity of light, a momentary change of colour has likewise been observed in some of the fixed stars. Mr Melville says, that when one looks steadfastly at Sirius, or any bright star not much elevated above the horizon, its colour seems not to be constantly white, but appears tinged, at every twinkling, with red and blue. This observation Mr Melville puts among his queries, with respect to which he could not entirely satisfy himself; and he observes, that the separation of the colours by the refractive power of the atmosphere is, probably, too small to be perceived. But the supposition of Mr Michell above-mentioned will pretty well account for this circumstance, though it may be thought inadequate to the former case. For the red and blue rays being much fewer than those of the intermediate colours, and therefore much more liable to inequalities, from the common effect of chance, a small excess or defect in either of them will make a very sensible difference in the colour of the stars.

§ 3. Discoveries concerning the Reflection of Light.

However much the ancients might have been mistaken with regard to the nature of light, we find that ²³ they were acquainted with two very important observations concerning it; viz. that light is propagated in right lines, and that the angle of incidence is equal to the angle of reflection. Who it was that first made these important observations is not known. But indeed, important as they are, and the foundation of a great part of even the present system of optics, it is possible that, if he were known, he might not be allowed to have any share of merit, at least for the *former* of them; the fact is so very obvious, and so easily ascertained. As to the latter, that *the angle of incidence is equal to the angle of reflection*, it was probably first discovered by observing a ray of the sun reflected from the surface of water, or some other polished body; or from observing the images of objects reflected by such surfaces. If philosophers attended to this phenomenon at all, they could not but take notice, that, if the ray fell nearly perpendicular upon such a surface, it was reflected near the perpendicular; and if it fell obliquely, it was reflected obliquely: and if they thought of applying any kind of measures to these angles, however coarse and imperfect, they could not but see that there was sufficient reason to assert their equality. At the same time they could not but know that the incident and reflected rays were both in the same plane.

Aristotle was sensible that it is the reflection of light from the atmosphere which prevents total darkness after the sun sets, and in places where he doth not shine in the day-time. He was also of opinion, that rainbows, halos, and mock suns, were all occasioned by the reflection of the sun-beams in different circumstances, by which an imperfect image of his body was produced, the colour only being exhibited, and not his proper figure. The image, he says, is not single, as in a mirror; for each drop of rain is too small to reflect a visible image, but the conjunction of all the images is visible.

Without inquiring any farther into the nature of ²⁴ light or vision, the ancient geometricians contented themselves with deducing a system of optics from the *Euclid's treatise of optics*. two observations mentioned above, viz. the rectilinear progress of light, and the equality of the angles of incidence and reflection. The treatise of optics which has been ascribed to Euclid is employed about determining the apparent size and figure of objects, from the angle under which they appear, or which the extremities of them subtend at the eye, and the apparent place of the image of an object reflected from a polished mirror; which he fixes at the place where the reflected ray meets a perpendicular to the mirror drawn through the object. But this work is so imperfect, and so inaccurately drawn up, that it is not generally thought to be the production of that great geometer.

It appears from a circumstance in the history of ²⁵ So- crates, that the effects of burning-glasses had also been observed by the ancients; and it is probable that the Romans had a method of lighting their sacred fire by means of a concave speculum. It seems indeed to have been known pretty early, that there is an in-crease

crease of heat in the place where the rays of light meet, when they are reflected from a concave mirror. The burning power of concave mirrors is taken notice of by Euclid in the second book of the treatise above-mentioned. If we give but a small degree of credit to what some ancient historians are said to have written concerning the exploits of Archimedes, we shall be induced to think that he made great use of this principle, in constructing some very powerful burning-mirrors; but nothing being said of other persons making use of his inventions, the whole account is very doubtful. It is allowed, however, that this eminent geometrician did write a treatise on the subject of burning-mirrors, though it be not now extant.

Plate
CCCLII.

B. Porta supposes that the burning-mirrors of the ancients were of metal, in the form of a section of a parabola. It follows from the properties of this curve, that all the rays which fall upon it, parallel to its axis, will meet in the same point at the focus. Consequently, if the vertex of the parabola be cut off, as in fig. 1. it will make a convenient burning-mirror. In some drawings of this instrument the frustum is so small, as to look like a ring. With an instrument of this kind, it is thought, that the Romans lighted their sacred fire. Some have also thought that this was the form of the mirror with which Archimedes burnt the Roman fleet; using either a lens, to throw the rays parallel, when they had been brought to a focus; or applying a smaller parabolic mirror for this purpose, as is represented fig. 2. But Dechales shows, that it is impossible to convey any rays in a direction parallel to one another, except those that come from the same point in the sun's disk.

26
Of seeing
images in
the air.

All this time, however, the nature of reflection was very far from being understood. Even lord Bacon, who made much greater advances in natural philosophy than his predecessors, and who pointed out the true method of improving it, was so far deceived with regard to the nature of reflection and refraction, that he supposed it possible to see the image reflected from a looking-glass, without seeing the glass itself; and to this purpose he quotes a story of friar Bacon, who is reported to have apparently walked in the air between two steeples, and which was thought to have been effected by reflection from glasses while he walked upon the ground.

The whole business of seeing images in the air may be traced up to Vitellio; and what he said upon the subject seems to have passed from writer to writer, with considerable additions, to the time of lord Bacon. What Vitellio endeavours to show is, that it is possible, by means of a cylindrical convex speculum, to see the images of objects in the air, out of the speculum, when the objects themselves cannot be seen. But, if his description of the apparatus requisite for this experiment be attended to, it will be seen that the eye was to be directed towards the speculum, which was placed within a room, while both the object and the spectator were without it. But though he recommends this observation to the diligent study of his readers, he has not described it in such a manner as is very intelligible; and, indeed, it is certain, that no such effect can be produced by a convex mirror. If he himself did make any trial with the apparatus that he describes

for this purpose, he must have been under some deception with respect to it.

B. Porta says, that this effect may be produced by a plane mirror only; and that an ingenious person may succeed in it: but his more particular description of a method to produce this extraordinary appearance is by a plane mirror and a concave one combined.

Kircher also speaks of the possibility of exhibiting these pendulous images, and supposes that they are reflected from the dense air; and the most perfect and pleasing deception depending upon the images in the air is one of which this writer gives a particular account in his *Ars Magna Lucis et Umbra*, p. 783. In this case the image is placed at the bottom of a hollow polished cylinder, by which means it appears like a real solid substance, suspended within the mouth of the vessel. In this manner, he says, he once exhibited a representation of the ascension of Christ; when the images were so perfect, that the spectators could not be persuaded, but by attempting to handle them, that they were not real substances.

Among other amusing things that were either invented or improved by Kircher, was the method of throwing the appearance of letters, and other forms of things, into a darkened room from without, by means of a lens and a plane mirror. The figures or letters were written upon the face of the mirror, and inverted; and the focus of the lens was contrived to fall upon the screen or wall that received their images. In this manner, he says, that with the light of the sun he could throw a plain and distinct image 500 feet.

It was Kepler who first discovered the true reason²⁷ of the apparent places of objects seen by reflecting mirrors, as it depends upon the angle which the rays of light, issuing from the extreme part of an object, make with one another after such reflections. In plane mirrors these rays are reflected with the same degree of inclination to one another that they had before their incidence; but he shows that this inclination is changed in convex and concave mirrors. Discoveries of Kepler.

Mr. Boyle made some curious observations concerning the reflecting powers of differently coloured substances. Many learned men, he says, imagined that snow affects the eyes, not by a *borrowed*, but by a *native* light; but having placed a quantity of snow in a room from which all foreign light was excluded, neither he nor any body else was able to perceive it. To try whether white bodies reflect more light than others, he held a sheet of white paper in a sun-beam admitted into a darkened room; and observed that it reflected much more light than a paper of any other colour, a considerable part of the room being enlightened by it. Farther, to show that white bodies reflect the rays outwards, he adds, that common burning-glasses will not of a long time burn or discolour white paper. When he was a boy, he says, and took great pleasure in making experiments with these glasses, he was much surprised at this remarkable circumstance; and it set him very early upon guessing at the nature of whiteness, especially as he observed that the image of the sun was not so well defined upon white paper as upon black; and as, when he put ink upon the paper, the moisture would be quickly dried up, and the paper, which he could not burn before, would presently take fire.²⁸ Of Mr Boyle.

fire. He also found, that, by exposing his hand to the sun, with a thin black glove upon it, it would be suddenly and more considerably heated, than if he held his naked hand to the rays, or put on a glove of thin white leather.

To prove that black is the reverse of white, with respect to its property of reflecting the rays of the sun, he procured a large piece of black marble; and having got it ground into the form of a large spherical concave speculum, he found that the image of the sun reflected from it was far from offending or dazzling his eyes, as it would have done from another speculum; and though this was large, he could not in a long time set a piece of wood on fire with it; though a far less speculum, of the same form, and of a more reflecting substance, would presently have made it flame.

To satisfy himself still farther with respect to this subject, he took a broad and large tile; and having made one half of its surface white and the other black, he exposed it to the summer sun. And having let it lie there some time, he found, that while the whited part remained cool, the part that was black was grown very hot. For his farther satisfaction, he sometimes left part of the tile of its native red; and, after exposing the whole to the sun, observed that this part grew hotter than the white, but was not so hot as the black part. He also observes, that rooms hung with black are not only darker than they would otherwise be, but warmer too; and he knew several persons, who found great inconvenience from rooms hung with black. As another proof of his hypothesis, he informs us, that a virtuoso, of unsuspected credit, acquainted him, that, in a hot climate, he had seen eggs well roasted in a short time, by first blacking the shells, and then exposing them to the sun.

²⁹
Of the infusion of lignum nephriticum. We have already taken notice of the remarkable property of lignum nephriticum first observed by Kircher. (See *GUILLANDINA*.) However, all his observations with regard to it fell very short of Mr Boyle. He describes this lignum nephriticum to be a whitish kind of wood, that was brought from Mexico, which the natives call *coatli* or *tlapazatl*, and which had been thought to tinge water of a green colour only; but he says that he found it to communicate all kinds of colours. If, says he, an infusion of this wood be put into a glass globe, and exposed to a strong light, it will be as colourless as pure water; but if it be carried into a place a little shaded, it will be a most beautiful green. In a place still more shaded, it will incline to red; and in a very shady place, or in an opaque vessel, it will be green again.

A cup of this remarkable wood was sent to Kircher by the procurator of his society at Mexico, and was presented by him to the emperor as a great curiosity. It is called *lignum nephriticum*, because the infusion of it was imagined to be of service in diseases of the kidneys and bladder, and the natives of the country where it grows do make use of it for that purpose.

Mr Boyle corrected several of the hasty observations of Kircher concerning the colours that appear in the infusion of lignum nephriticum, and he diversified the experiments with it in a very pleasing manner. He first distinctly noted the two very different colours which this remarkable tincture exhibits by transmit-

ted and reflected light. If, says he, it be held directly between the light and the eye, it will appear tinged (excepting the very top of it, where a sky-coloured circle sometimes appears) almost of a golden colour, except the infusion be too strong; in which case it will be dark or reddish, and requires to be diluted with water. But if it be held from the light, so that the eye be between the light and the phial, it will appear of a deep lovely blue colour; as will also the drops, if any lie on the outside of the glass.

When a little of this tincture was poured upon a sheet of white paper, and placed in a window where the sun could shine upon it, he observed, that if he turned his back upon the sun, the shadow of his pen, or any such slender substance, projected upon the liquor, would not be all dark, like other shadows; but that part of it would be curiously coloured, the edge of it next the body being almost of a lively golden colour, and the more remote part blue. These, and other experiments of a similar nature, many of his friends, he says, beheld with wonder; and he remembered an excellent oculist, who accidentally meeting with a phial full of this liquor, and being unacquainted with this remarkable property of it, imagined, after he had viewed it a long time, that some new and strange distemper had seized his eyes: and Mr Boyle himself acknowledges, that the oddness of the phenomenon made him very desirous to find out the cause of it; and his inquiries were not altogether unsuccessful.

Observing that this tincture, if it were too deep, was not tinged in so beautiful a manner, and that the impregnating virtue of the wood did, by being frequently infused in fresh water, gradually decay, he conjectured that the tincture contained much of the essential salt of the wood; and to try whether the subtle parts, on which the colour depended, were volatile enough to be distilled, without dissolving their texture, he applied some of it to the gentle heat of a lamp-furnace; but he found all that came over was as limpid and colourless as rock water, while that which remained behind was of so deep a blue, that it was only in a very strong light that it appeared of any colour.

Suspecting that the tinging particles abounded with salts, whose texture, and the colour thence arising, would probably be altered by acids, he poured into a small quantity of it a very little spirit of vinegar, and found that the blue colour immediately vanished, while the golden one remained, on which ever side it was viewed with respect to the light.

Upon this he imagined, that as the acid salts of the vinegar had been able to deprive the liquor of its blue colour, a sulphureous salt, which is of a contrary nature, would destroy their effects; and having placed himself betwixt the window and the phial, and let fall into the same liquor a few drops of oil of tartar *per deliquium*, he found that it was immediately restored to its former blue colour, and exhibited all the same phenomena which it had done at the first.

Having sometimes brought a round long-necked phial, filled with this tincture, into a darkened room, into which a beam of the sun was admitted by a small aperture; and holding the phial sometimes near the sun-beams, and sometimes partly in them and partly

out.

out of them, changing also the position of the glass, and viewing it from several parts of the room, it exhibited a much greater variety of colours than it did in an enlightened room. Besides the usual colours, it was red in some places and green in others, and within were intermediate colours produced by the different degrees and odd mixtures of light and shade.

It was not only in this tincture of *lignum nephriticum* that Mr Boyle observed the difference between reflected and transmitted light. He observed it even in gold, though no person explained the cause of these effects before Sir Isaac Newton. He took a piece of leaf-gold, and holding it betwixt his eye and the light, observed that it did not appear of a golden colour, but of a greenish blue. He also observed the same change of colour by candle-light; but the experiment did not succeed with a leaf of silver.

The constitution of the atmosphere and of the sea, we shall find, by observations made in later periods, to be similar to that of this infusion; for the blue rays, and others of a faint colour, do not penetrate so far into them as the red, and others of a stronger colour: but what this constitution is, which is common to them all, deserves to be inquired into. For almost all other tinctures, and this of *lignum nephriticum* too, after some change made in it by Mr Boyle, as well as all other semi-transparent coloured substances, as glass, appear of the same hue in all positions of the eye. To increase or diminish the quantity makes no difference, but to make the colour deeper or more dilute.

³⁰
Mr Boyle's
account of
the colours
of thin
plates.

The first distinct account of the colours exhibited by thin plates of various substances, are met with among the observations of Mr Boyle. To show the chemists that colours may be made to appear or vanish, where there is no accession or change either of the sulphureous, the saline, or the mercurial principle of bodies, he observes, that all chemical essential oils, as also good spirit of wine, being shaken till they rise in bubbles, appear of various colours; which immediately vanish when the bubbles burst, so that a colourless liquor may be immediately made to exhibit a variety of colours, and lose them in a moment, without any change in its essential principles. He then mentions the colours that appear in bubbles of soap and water, and also in turpentine. He sometimes got glass blown so thin as to exhibit similar colours; and observes, that a feather, of a proper shape and size, and also a black ribbon, held at a proper distance, between his eye and the sun, showed a variety of little rainbows, as he calls them, with very vivid colours, none of which were constantly to be seen in the same objects.

³¹
Dr Hooke's
account of
these co-
lours.

Much more pains were taken with this subject, and a much greater number of observations respecting it were made, by Dr Hooke. As he loved to give surprise by his discoveries, he promised, at a meeting of the society on the 7th of March 1672, to exhibit, at their next meeting, something which had neither reflection nor refraction, and yet was diaphanous. Accordingly, at the time appointed, he produced the famous coloured bubble of soap and water, of which such admirable use was afterwards made by Sir Isaac Newton, but which Dr Hooke and his contemporaries

seem to have overlooked in Mr Boyle's treatise on colours, though it was published nine years before. It is no wonder that so curious an appearance excited the attention of that inquisitive body, and that they should desire him to bring an account of it in writing at their next meeting.

By the help of a small glass-pipe, there were blown several small bubbles, out of a mixture of soap and water; where it was observable, that, at first, they appeared white and clear; but that, after some time, the film of water growing thinner, there appeared upon it all the colours of the rainbow: First a pale yellow; then orange, red, purple, blue, green, &c. with the same series of colours repeated; in which it was farther observable, that the first and last series were very faint, and that the middlemost order or series was very bright. After these colours had passed over the changes above-mentioned, the film of the bubble began to appear white again; and presently, in several parts of this second white film, there appeared several holes, which by degrees grew very big, several of them running into one another. After reciting other observations, which are not of much consequence, he says it is strange, that though both the encompassing and encompassed air have surfaces, yet he could not observe that they afforded either reflection or refraction, which all the other parts of the encompassed air did. This experiment, he says, at first sight, may appear very trivial, yet, as to the finding out the nature and cause of reflection, refraction, colours, congruity and incongruity, and several other properties of bodies, he looked upon it as one of the most instructive. And he promised to consider it more afterwards; but we do not find that ever he did; nor indeed is it to be much regretted, as we shall soon find this business in better hands. He adds, that that which gives one colour by reflection, gives another by trajection; not much unlike the tincture of *lignum nephriticum*.

Dr Hooke was the first to observe, if not to describe, the beautiful colours that appear in thin plates of muscovy glass. These, he says, are very beautiful to the naked eye, but much more when they are viewed with a microscope. With this instrument he could perceive that these colours were ranged in rings surrounding the white specks or flaws in this thin substance, that the order of the colours was the very same as in the rainbow, and that they were often repeated ten times. But the colours, he says, were disposed as in the outer bow, and not the inner. Some of them also were much brighter than others, and some of them very much broader. He also observed, that if there was a place where the colours were very broad, and conspicuous to the naked eye, they might be made, by pressing the place with the finger, to change places, and move from one part to another. Lastly, he observed, that if great care be used, this substance may be split into plates of $\frac{1}{8}$ or $\frac{1}{10}$ of an inch in diameter, each of which will appear through a microscope to be uniformly adorned with some one vivid colour, and that these plates will be found upon examination to be of the same thickness throughout.

As a fact similar to this, but observed previous to it, we shall here mention that Lord Brereton, at a meeting of the Royal Society in 1666, produced some pieces

pieces of glass taken out of a window of a church, both on the north and on the south side of it; observing, that they were all eaten in by the air, but that the piece taken from the south side had some colours like those of the rainbow upon it, which the others on the north side had not. This phenomenon has been frequently observed since, and in other circumstances. It is not to be doubted, but that in all these cases, the glass is divided into thin plates, which exhibit colours, upon the same principle with those which Dr Hooke observed in the bubble of soap and water, and in the thin plate of air, which we shall find more fully explained by Sir Isaac Newton. With care the thin plates of the glass may be separated, and the theory verified.

³² Why the stars are visible by day at the bottom of a well. An observation made by Otto Guericke, well explains the reason why stars are visible at the bottom of a deep well. It is, says he, because the light that proceeds from them is not overpowered by the rays of the sun, which are lost in the number of reflections which they must undergo in the pit, so that they can never reach the eye of a spectator at the bottom of it.

But of all those who have given their attention to this subject of the reflection of light, none seems to have given such satisfaction as M. Bouguer; and next to those of Sir Isaac Newton, his labours seem to have been the most successful. The object of his curious and elaborate experiments was to measure the degrees of light, whether emitted, reflected, or refracted, by different bodies. They were originally occasioned by an article of M. Mairan's in the memoirs of the French academy for 1721, in which the proportion of the light of the sun at the two solstices were supposed to be known; and his laudable attempt to verify what had been before taken for granted, suggested a variety of new experiments, and opened to him and to the world a new field of optical knowledge. His first production upon this subject was a treatise intitled *Essai d'Optique*, which was received with general approbation. Afterwards, giving more attention to this subject, he formed an idea of a much larger work, to which many more experiments were necessary: but he was prevented, by a variety of interruptions, from executing his design so soon as he had proposed; and he had hardly completed it at the time of his death, in 1758; so that we are obliged to his friend M. de la Caille for the care of the publication. At length, however, it was printed at Paris in 1760, under the title of *Traité d'Optique*.

³³ Discoveries of M. Bouguer. At the entrance upon this treatise, we are induced to form the most pleasing expectations from our author's experiments, by his account of the variety, the singular accuracy, and circumspection, with which he made them; whereby he must, to all appearance, have guarded against every avenue to error, and particularly against those objections to which the few attempts that had been made, of a similar nature, before him had been liable. In order to compare different degrees of light, he always contrived to place the bodies from which it proceeded, or other bodies illuminated by them, in such a manner as that he could view them distinctly at the same time; and he either varied the distances of these bodies, or modified their light in some other way, till he could perceive no difference between

them. Then, considering their different distances, or the other circumstances by which their light was affected, he calculated the proportion which they would have borne to each other at the same distance, or in the same circumstances.

To ascertain the quantity of light lost by reflection, he placed the mirror, or reflecting surface, B, on which the experiment was to be made, truly upright; and having taken two tablets, of precisely the same colour, or of an equal degree of whiteness, he placed them exactly parallel to one another at E and D, and threw light upon them by means of a lamp or candle, P, placed in a right line between them. He then placed himself so, that with his eye at A he could see the tablet E, and the image of the tablet D, reflected from the mirror B, at the same time; making them, as it were, to touch one another. He then moved the candle along the line ED, so as to throw more or less light upon either of them, till he could perceive no difference in the strength of the light that came to his eye from them. After this, he had nothing more to do than to measure the distances EP and DP; for the squares of those distances expressed the degree in which the reflection of the mirror diminished the quantity of light. It is evident, that if the mirror reflected all the rays it received, the candle P must have been placed at C, at an equal distance from each of the tablets, in order to make them appear equally illuminated; but because much of the light is lost in reflection, they can only be made to appear equally bright by placing the candle nearer the tablet D, which is seen by reflection only.

To find how much light is lost by oblique reflection, he took two equally polished plates, D and E, and caused them to be enlightened by the candle P; and while one of them, D, was seen at A, by reflection from B, placed in a position oblique to the eye, the other, E, was so placed, as to appear contiguous to it; and removing the plate E, till the light which it reflected was no stronger than that which came from the image D, seen by reflection at B, he estimated the quantity of light that was lost by this oblique reflection, by the squares of the distances of the two objects from the candle.

It need scarcely be added, that in these experiments all foreign light was excluded, that his eye was shaded, and that every other precaution was observed in order to make his conclusions unquestionable.

In order to ascertain the quantity of light lost by reflection with the greatest exactness, M. Bouguer introduced two beams of light into a darkened room, as by the apertures P and Q; which he had so contrived, that he could place them higher or lower, and enlarge or contract them at pleasure; and the reflecting surface (as that of a fluid contained in a vessel) was placed horizontally at O, from whence the light coming through the hole P, was reflected to R, upon the screen GH, where it was compared with another beam of light that fell upon S, through the hole Q; which he made so much less than P, as that the spaces S and R were equally illuminated; and by the proportion that the apertures P and Q bore to each other, he calculated what quantity of light was lost by the reflection at O.

It was necessary, he observes, that the two beams of light

Plate
CCCLII.
fig. 3.

Fig. 4.

Fig. 5.

light PO and QS (which he usually made 7 or 8 feet long) should be exactly parallel, that they might come from two points of the sky equally elevated above the horizon, and having precisely the same intensity of light. It was also necessary that the hole Q should be a little higher than P, in order that the two images should be at the same height, and near one another. It is no less necessary, he says, that the screen GH be exactly vertical, in order that the direct and reflected beams may fall upon it with the same inclination; since, otherwise, though the two lights were perfectly equal, they would not illuminate the screen equally. This disposition, he says, serves to answer another important condition in these experiments; for the direct ray QS must be of the same length with the sum of the incident and reflected rays, PO and OR, in order that the quantity of light introduced into the room may be sensibly proportional to the sizes of the apertures.

We shall now proceed to recite the result of the experiments which he made to measure the quantity of light that is lost by reflection in a great variety of circumstances; but we shall introduce them by the recital of some which were made previous to them on the diminution of light by reflection, and the transmission of it to considerable distances through the air, by M. Buffon, at the time that he was constructing his machine to burn at great distances, mentioned under the article *BURNING-Glass*.

34
Of Mr Buffon.
Receiving the light of the sun in a dark place, and comparing it with the same light of the sun reflected by a mirror, he found, that at small distances, as four or five feet, about one half was lost by reflection; as he judged by throwing two reflected beams upon the same place, and comparing them with a beam of direct light; for then the intensity of them both seemed to be the same.

Having received the light at greater distances, as at 100, 200, and 300 feet, he could hardly perceive that it lost any of its intensity by being transmitted through such a space of air.

He afterwards made the same experiments with candles, in the following manner: He placed himself opposite to a looking-glass, with a book in his hand, in a room perfectly dark; and having one candle lighted in the next room, at the distance of about 40 feet, he had it brought nearer to him by degrees, till he was just able to distinguish the letters of the book, which was then 24 feet from the candle. He then received the light of the candle, reflected by the looking-glass, upon his book, carefully excluding all the light that was reflected from any thing else; and he found that the distance of the book from the candle, including the distance from the book to the looking-glass (which was only half a foot) was in all 15 feet. He repeated the experiment several times, and always with nearly the same result; and therefore concluded, that the quantity of direct light is to that of reflected as 576 to 225; so that the light of five candles reflected from a plane mirror is about equal to that of two candles.

From these experiments it appeared, that more light was lost by reflection of the candles than of the sun, which M. Buffon thought was owing to this circumstance, that the light issuing from the candle diverges,
N^o 247.

and therefore falls more obliquely upon the mirror than the light of the sun, the rays of which are nearly parallel.

These experiments and observations of M. Buffon are curious; though it will be seen that they fall far short of those of M. Bouguer, both in extent and accuracy. We shall begin with those which he made to ascertain the difference in the quantity of light reflected by glass and polished metal.

Using a smooth piece of glass one line in thickness, Mr Bouguer's discovery concerning the reflection of glass and polished metal.
he found, that when it was placed at an angle of 15 degrees with the incident rays, it reflected 628 parts of 1000 which fell upon it; at the same time that a metallic mirror, which he tried in the same circumstances, reflected only 561 of them. At a less angle of incidence much more light was reflected; so that at an angle of three degrees the glass reflected 700 parts, and the metal something less, as in the former case.

Trying the reflection of bodies that were not polished, he found that a piece of white plaster, placed at an angle of 75°, with the incident rays, reflected $\frac{1}{10}$ part of the light that is received from a candle nine inches from it. White paper, in the same circumstances, reflected in the same proportion; but at the distance of three inches, they both reflected 150 parts of 1000 that were incident.

Proceeding to make farther observations on the subject of reflected light, he premises the two following theorems, which he demonstrates geometrically. 1. When the luminous body is at an infinite distance, and its light is received by a globe, the surface of which has a perfect polish, and absorbs no light, it reflects the light equally in all directions, provided it be received at a considerable distance. He only excepts the place where the shadow of the globe falls; but this, he says, is no more than a single point, with respect to the immensity of the spherical surface which receives its light.

2. The quantity of light reflected in one certain direction will always be exactly the same, whether it be reflected by a very great number of small polished hemispheres, by a less number of larger hemispheres, or by a single hemisphere, provided they occupy the same base, or cover the same ground-plan.

The use he proposes to make of these theorems is to assist him in distinguishing whether the light reflected from bodies be owing to the extinction of it within them, or whether the roughness or eminences which cover them have not the same effect with the small polished hemispheres above-mentioned.

He begins with observing, that, of the light reflected from Mercury, $\frac{1}{4}$ at least is lost, and that probably no substances reflect more than this. The rays were received at an angle of 11½ degrees of incidence, that is measured from the surface of the reflecting body, and not from the perpendicular, which, he says, is what we are from this place to understand whenever he mentions the angle of incidence.

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The most striking observations which he made with Great difference in the reflective power of substances according to the angle of incidence.
respect to this subject, are those which relate to the very great difference in the quantity of light reflected at different angles of incidence. In general, he says, that reflection is stronger at small angles of incidence, and weaker at large ones. The difference is excessive when the rays strike the surface of transparent substances,

stances, with different degrees of obliquity; but it is almost as great in some opaque substances, and it was always more or less so in every thing that he tried. He found the greatest inequality in black marble; in which he was astonished to find, that, with an angle of $3^{\circ} 35'$ of incidence, though not perfectly polished, yet it reflected almost as well as quicksilver. Of 1000 rays which it received, it returned 600; but when the angle of incidence was 14 degrees, it reflected only 156; when it was 30, it reflected 51; and when it was 80, it reflected only 23.

Similar experiments made with metallic mirrors always gave the differences much less considerable. The greatest was hardly ever an eighth or a ninth part of it, but they were always in the same way.

The great difference between the quantity of light reflected from the surface of water, at different angles of incidence, is truly surprising; but our author observes, that this difference was greater when the smallest inclinations were compared with those which were near to a right angle. He sometimes suspected, that, at very small angles of incidence, the reflection from water was even greater than from quicksilver. All things considered, he thought it was not quite so great, though it was very difficult to determine the precise difference between them. In very small angles, he says, that water reflects nearly $\frac{1}{4}$ of the direct light.

There is no person, he says, but has sometimes felt the force of this strong reflection from water, when he has been walking in still weather on the brink of a lake opposite to the sun. In this case, the reflected light is $\frac{1}{3}$, $\frac{1}{2}$, or sometimes a greater proportion of the light that comes directly from the sun, which is an addition to the direct rays of the sun that cannot fail to be very sensible. The direct light of the sun diminishes gradually as it approaches the horizon, while the reflected light at the same time grows stronger: so that there is a certain elevation of the sun, in which the united force of the direct and reflected light will be the greatest possible, and this he says is 12 or 13 degrees.

On the other hand, the light reflected from water at great angles of incidence is extremely small. Our author was assured, that, when the light was perpendicular, it reflected no more than the 37th part that quicksilver does in the same circumstances; for it did not appear, from all his observations, that water reflects more than the 60th, or rather the 55th, part of perpendicular light. When the angle of incidence was 50 degrees, the light reflected from the surface of water was about the 32d part of that which mercury reflected; and as the reflection from water increases with the diminution of the angle of incidence, it was twice as strong in proportion at 39 degrees; for it was then the 16th part of the quantity that mercury reflected.

In order to procure a common standard by which to measure the proportion of light reflected from various fluid substances, he pitched upon water as the most commodious; and partly by observation, and partly by calculation, which he always found to agree with his observations, he drew up the following table of the quantity of light reflected from the surface of water, at different angles with the surface.

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Angles of incidence.	Rays reflected of 1000.	Angles of incidence.	Rays reflected of 1000.
$\frac{1}{2}$	721	$17 \frac{1}{2}$	178
1	692	20	145
$1 \frac{1}{2}$	669	25	97
2	639	30	65
$2 \frac{1}{2}$	614	40	34
5	501	50	22
$7 \frac{1}{2}$	409	60	19
10	333	70	18
$12 \frac{1}{2}$	271	80	18
15	211	90	18

In the same manner, he drew up the following table of the quantity of light reflected from the looking-glass not quicksilvered.

Angles of incidence.	Rays reflected of 1000.	Angles of incidence.	Rays reflected of 1000.
$2 \frac{1}{2}$	584	30	112
5	543	40	57
$7 \frac{1}{2}$	474	50	34
10	412	60	27
$12 \frac{1}{2}$	356	70	25
15	299	80	25
20	222	90	25
25	157		

Pouring a quantity of water into a vessel containing quicksilver, it is evident that there will be two images of any objects seen by reflection from them, one at the surface of the water, and the other at that of the quicksilver. In the largest angles of incidence, the image at the surface of the water will disappear, which will happen when it is about a 60th or an 80th part less luminous than the image at the surface of the quicksilver. Depressing the eye, the image on the water will grow stronger, and that on the quicksilver weaker in proportion; till at last, the latter will be incomparably weaker than the former, and at an angle of about 10 degrees they will be equally luminous. According to the table, $\frac{333}{1000}$ of the incident rays are reflected from the water at this angle of 10 degrees. At the surface of the mercury they were reduced to 500; and of these, part being reflected back upon it from the under surface of the water, only 333 remained to make the image from the mercury.

It has been observed by several persons, particularly ³⁷ Reflection by Mr Edwards, (see Phil. Trans. vol. 53. p. 229.) of images that there is a remarkably strong reflection into water, by the air, with respect to rays issuing from the water; and persons under water have seen images of things in the air in a manner peculiarly distinct and beautiful: but this fact had not been observed with a sufficient degree of attention, till it came into M. Bouguer's way to do it, and he acknowledges it to be very remarkable. In this case, he says, that from the smallest angles of incidence, to a certain number of degrees, the greatest part of the rays are reflected, perhaps in as great a proportion as at the surface of metallic mirrors, or of quicksilver; while the other part, which

I i

does

does not escape into the air, is extinguished or absorbed; so that the surface of the transparent body appears opaque on the inside. If the angle of incidence be increased only a few degrees, the strong reflection ceases altogether, a great number of rays escape into the air, and very few are absorbed or extinguished. In proportion as the angle of incidence is farther increased, the quantity of the light reflected becomes less and less; and when it is near 90 degrees, almost all the rays escape out of the transparent body, its surface losing almost all its power of reflection, and becoming almost as transparent as it is in other cases, or when the light falls upon it from without.

38
Extinction
of the rays
of light at
the surface
of transpa-
rent bodies.

This property belonging to the surfaces of transparent bodies, of absorbing or extinguishing the rays of light, is truly remarkable, and, as there is reason to believe, had not been noticed by any person before M. Bouguer. It had been conjectured by Sir Isaac Newton, that rays of light become extinct only by impinging upon the solid parts of bodies; but these observations of M. Bouguer show that the fact is quite otherwise; and that this effect is to be attributed, not to the solid parts of bodies, which are certainly more numerous in a long tract of water than just in the passage out of water into air, but to some power lodged at the surfaces of bodies only, and therefore probably the same with that which reflects, refracts, and inflects the light.

39
Strong re-
flection by
a prism.

One of the above-mentioned observations, viz. all the light being reflected at certain angles of incidence from air into denser substances, had frequently been made, especially in glass prisms; so that Newton made use of one of them, instead of a reflecting mirror, in the construction of his telescope. If a beam of light fall upon the air from within these prisms, at an angle of 10, 20, or 30 degrees, the effect will be nearly the same as at the surface of quicksilver, a fourth or a third of the rays being extinguished, and $\frac{2}{3}$ or $\frac{1}{3}$ ths reflected. This property retains its full force as far as an incidence of $49^{\circ} 49'$, (supposing the proportion of the sines of refraction to be 31 and 20 for the mean refrangible rays); but if the angle of incidence be increased but one degree, the quantity of light reflected inwards decreases suddenly, and a great part of the rays escape out of the glass, so that the surface becomes suddenly transparent.

All transparent bodies have the same property, with this difference, that the angle of incidence at which the strong reflection ceases, and at which the light which is not reflected is extinguished, is greater in some than in others. In water this angle is about $41^{\circ} 32'$; and in every medium it depends so much on the invariable proportion of the sine of the angle of refraction to the sine of the angle of incidence, that this law alone is sufficient to determine all the phenomena of this new circumstance, at least as to this accidental opacity of the surface.

When our author proceeded to measure the quantity of light reflected by these internal surfaces at great angles of incidence, he found many difficulties, especially on account of the many alterations which the light underwent before it came to his eye: but at length, using a plate of crystal, he found, that, at an angle of 75 degrees, this internal reflection diminished the light 27 or 28 times; and as the external re-

flection at the same angle diminished the light only 26 times, it follows that the internal reflection is a little stronger than the other.

Repeating these experiments with the same and different pieces of crystal, he sometimes found the two reflections to be equally strong; but, in general, the internal was the stronger. Also, the image reflected internally was always a little redder than an object which was seen directly through the plate of crystal.

Resuming his observations on the diminution of light, occasioned by the reflection of opaque bodies obliquely situated, he compared it with the appearances of similar substances which reflected the light perpendicularly. Using pieces of silver made very white, he found, that, when one of them was placed at an angle of 75 degrees with respect to the light, it reflected only 640 parts out of 1000. He then varied the angle, and also used white plaster and fine Dutch paper, and drew up the following table of the proportion of the light reflected from each of those substances at certain angles.

QUANTITY of LIGHT reflected from

Angles of incidence.	Silver.	Plaster.	Dutch Paper.
90	1000	1000	1000
75	802	762	971
60	640	640	743
45	455	519	507
30	319	352	332
15	209	194	203

Supposing the asperities of opaque bodies to consist of very small planes, it appears from these observations, that there are fewer of them in those bodies which reflect the light at small angles of incidence than at greater; and our author says, that the case was nearly the same with respect to all the opaque bodies that he tried. None of them had their roughness equivalent to small hemispheres, which would have dispersed the light equally in all directions; and, from the data in the preceding table, he deduces mathematically the number of the little planes that compose those surfaces, and that are inclined to the general surface at the angles above-mentioned, supposing that the whole surface contains 1000 of them that are parallel to itself, so as to reflect the light perpendicularly, when the luminous body is situated at right angles with respect to it. His conclusions reduced to a table, corresponding to the preceding, are as follow:

Inclinations of the small surfaces with respect to the large one.	The distribution of the small planes that constitute the asperities of the opaque surface in the		
	Silver.	Plaster.	Paper.
0	1000	1000	1000
15	777	736	937
30	554	554	545
45	333	374	358
60	161	176	166
75	53	50	52

These

These variations in the number of little planes, or surfaces, he expresses in the form of a curve; and afterwards he shows, geometrically, what would be the effect if the bodies were enlightened in one direction, and viewed in another; upon which subject he has several curious theorems and problems: as, the position of the eye being given, to find the angle at which the luminous body must be placed, in order to its reflecting the most light; or, the situation of the luminous body being given, to find a proper situation for the eye, in order to see it the most enlightened, &c. But it would carry us too far into geometry to follow him through all these disquisitions.

41
Observations concerning the planets, &c.

Since the planets, as this accurate observer takes notice, are more luminous at their edges than at their centres, he concludes, from the above-mentioned principles, that the bodies which form them are constituted in a manner different from ours; particularly that their opaque surfaces consist of small planes, more of which are inclined to the general surface than they are in terrestrial substances; and that there are in them an infinity of points, which have exactly the same splendour.

Our philosopher and geometrician next proceeds to ascertain the quantity of surface occupied by the small planes of each particular inclination, from considering the quantity of light reflected by each, allowing those that have a greater inclination to the common surface to take up proportionably less space than those which are parallel to it. And comparing the quantity of light that would be reflected by small planes thus disposed, with the quantity of light that was actually reflected by the three substances above-mentioned, he found, that plaster, notwithstanding its extreme whiteness, absorbs much light; for that, of 1000 rays that fall upon it, of which 166 or 167 ought to be reflected at an angle of 77 degrees, only 67 are in fact returned; so that 100 out of 167 were extinguished, that is, about three-fifths.

With respect to the planets, our author concludes, that of 300,000 rays which the moon receives, 172,000 are absorbed, or perhaps 204,100.

42
Of the surfaces of bodies.

Having considered the surfaces of bodies as consisting of planes only, he thus explains himself.—Each small surface, separately taken, is extremely irregular, and some of them are really concave, and others convex; but, in reducing them to a middle state, they are to be considered as planes. Nevertheless he considers them as planes only with respect to the reception of the rays; for as they are almost all curves, and as, besides this, many of those whose situation is different from others contribute to the same effect, the rays always issue from an actual or imaginary focus, and after reflection always diverge from another.

If it be asked, what becomes of those rays that are reflected from one asperity to another? he shows that very few of the rays can be in those circumstances; since they must fall upon planes which have more than 45 degrees of obliquity to the surface, of which there are very few in natural bodies. These rays must also fall at the bottom of those planes, and must meet with other planes similarly situated to receive them; and considering the great irregularity of the surfaces of opaque bodies, it may be concluded that very few of the rays are thus reflected upon the body itself; and

that the little that is so reflected is probably lost to the spectators, being extinguished in the body.

43
Mr Melville's observations on the manner in which bodies are heated by light.

We are obliged to Mr Melville for some ingenious observations on the manner in which bodies are heated by light. He observes, that, as each colorific particle of an opaque body must be somewhat moved by the reaction of the particles of light, when it is reflected backwards and forwards between the same particles, it is manifest that they must likewise be agitated with a vibratory motion, and the time of a vibration will be equal to that which light takes up in moving from one particle of a body to another adjoining. This distance, in the most solid opaque bodies, cannot be supposed greater than $\frac{1}{113,000}$ th of an inch, which space a particle of light describes in the $\frac{1}{113,000,000,000,000}$ th of a second. With so rapid a motion, therefore, may the internal parts of bodies be agitated by the influence of light, as to perform 125,000,000,000,000 vibrations, or more, in a second of time.

The arrival of different particles of light at the surface of the same colorific particle, in the same or different rays, may disturb the regularity of its vibrations, but will evidently increase their frequency, or raise still smaller vibrations among the parts which compose those particles; by which means the intestine motion will become more subtle, and more thoroughly diffused. If the quantity of light admitted into the body be increased, the vibrations of the particles must likewise increase in magnitude and velocity, till at last they may be so violent, as to make all the component particles dash one another to pieces by their mutual collision; in which case, the colour and texture of the body must be destroyed.

Since there is no reflection of light but at the surface of a medium, the same person observes, that the greatest quantity of rays, though crowded into the smallest space, will not of themselves produce any heat. From hence it follows, that the portion of air which lies in the focus of the most potent speculum, is not at all affected by the passage of light through it, but continues of the same temperature with the ambient air; though any opaque body, or even any transparent body denser than air, when put in the same place, would be intensely heated in an instant.

This consequence, evidently flowing from the plainest and most certain principles, not seeming to have been rightly understood by many philosophers, and even the silence of most physical writers concerning this paradoxical truth making it probable that they were unacquainted with it, he thought it worth his while to say something in explication of it. He observes, that the easiest way to be satisfied of the matter experimentally is, to hold a hair, or a piece of down, immediately above the focus of a lens or speculum, or to blow a stream of smoke from a pipe horizontally over it; for if the air in the focus were hotter than the surrounding fluid, it would continually ascend upon account of its rarefaction, and thereby sensibly agitate those slender bodies. Or a lens may be so placed as to form its focus within a body of water, or some other transparent substance, the heat of which may be examined from time to time with a thermometer; but care must be taken, in this experiment, to hold the lens as near as possible to the transparent body, lest the rays, by falling closer than ordinary on its surface,

surface, should warm it more than the common sun-beams (B).

To apply these observations to the explication of natural phenomena, he observes, that the atmosphere is not much warmed by the passage of the sun's light through it, but chiefly by its contact with the heated surface of the globe. This, he thought, furnished one very simple and plausible reason why it is coldest in all climates on the tops of very high mountains; namely, because they are removed to the greatest distance from the general surface of the earth. For it is well known, that a fluid heated by its contact with a solid body, decreases in heat in some inverse proportion to the distance from the body. He himself found, by repeated trials, that the heat of water in deep lakes decreases regularly from the surface downwards. But to have this question fully determined, the temperature of the air in the valley and on the mountain-top must be observed every hour, both night and day, and carefully compared together.

From this doctrine he thinks it reasonable to suppose, that the heat produced by a given number of rays, in an opaque body of a given magnitude, must be greater when the rays are more inclined to one another, than when they are less so; for the direction of the vibrations raised by the action of the light, whether in the colorific particles, or those of an inferior order, will more interfere with one another; from whence the intestine shocks and collisions must increase. Besides this, the colorific particles of opaque bodies being disposed in various situations, perhaps, upon the whole, the rays will fall more directly on each, the more they are inclined to one another. Is not this, says he, the reason of what has been remarked by philosophers, that the heat of the sun's light, collected into a cone, increases in approaching the focus in a much higher proportion than according to its density? That the difference of the angle in which the rays fall on any particle of a given magnitude, placed at different distances from the focus, is but small, is no proof that the phenomenon cannot be ascribed to it; since we know not in what high proportion one or both the circumstances now mentioned may operate. However, that it proceeds not from any unknown action of the rays upon one another, as has been insinuated, is evident from this, that each particular ray, after passing through the focus, preserves its own colour and its own direction, in the same manner as if it were alone.

44
Abbé Nol-
let's exper-
iment with
burning
glasses.

The attempts of the Abbé Nollet to fire inflammable substances by the power of the solar rays collected in the foci of burning mirrors, have a near relation to the present subject. Considering the great power of burning mirrors and lenses, especially those of late construction, it will appear surprising that this celebrated experimental philosopher should not be able to fire any liquid substance. But though he made the trial with all the care imaginable on the 19th of February 1757, he was not able to do it either with spirit of-wine, olive-oil, oil-of-turpentine, or æther;

and though he could fire sulphur, yet he could not succeed with Spanish wax, rosin, black pitch, or fuet. He both threw the focus of these mirrors upon the substances themselves, and also upon the fumes that rose from them; but all the effect was, that the liquor boiled, and was dispersed in vapour or very small drops, but would not take fire. When linen-rags, and other solid substances, were moistened with any of these inflammable liquids, they would not take fire till the liquid was dispersed in a copious fume; so that rags thus prepared were longer in burning than those that were dry.

M. Beaume, who assisted M. Nollet in some of these experiments, observed farther, that the same substances which were easily fired by the flame of burning bodies, could not be set on fire by the contact of the hottest bodies that did not actually flame. Neither æther nor spirit-of-wine could be fired with a hot coal, or even red-hot iron, unless they were of a white heat. From these experiments our author concludes, that, supposing the electric matter to be the same thing with fire or light, it must fire spirit-of-wine by means of some other principle. The members of the academy Del Cimento had attempted to fire several of these substances, though without success; but this was so early in the history of philosophy, that nobody seems to have concluded, that, because they failed in this attempt, the thing could not be done. However, the Abbé informs us, that he read an account of his experiments to the Royal Academy at Paris several years before he attended to what had been done by the Italian philosophers.

By the help of optical principles, and especially by observations on the reflection of light, Mr Melville discovered that bodies which seem to touch one another are not always in actual contact. "It is common (says he) to admire the volubility and lustre of drops of rain that lie on the leaves of colewort, and some other vegetables;" but no philosopher, as far as he knew, had put himself to the trouble of explaining this curious phenomenon. Upon inspecting them narrowly, he found that the lustre of the drop is produced by a copious reflection of light from the flattened part of its surface contiguous to the plant. He observed farther, that, when the drop rolls along a part which has been wetted, it immediately loses all its lustre, the green plant being then seen clearly through it; whereas, in the other case, it is hardly to be discerned.

From these two observations put together, he concluded, that the drop does not really touch the plant, when it has the mercurial appearance, but is suspended in the air at some distance from it by the force of a repulsive power. For there could not be any copious reflection of white light from its under-surface, unless there were a real interval between it and the surface of the plant.

If that surface were perfectly smooth, the under-surface of the drop would be so likewise, and would therefore show an image of the illuminating body by reflection.

(B) To these observations objections might be made which it would not perhaps be easy to answer; but we are at present giving only the history of optics.

reflection, like a piece of polished silver; but as it is considerably rough and unequal, the under-surface becomes rough likewise, and so, by reflecting the light copiously in different directions, assumes the resplendent white colour of unpolished silver.

It being thus proved by an optical argument, that the drop is not really in contact with the plant which supports it, it may easily be conceived whence its volubility arises, and why it leaves no moisture where it rolls.

Before we conclude the history of the observations concerning the reflection of light, we must not omit to take notice of two curious miscellaneous ones. Baron Alexander Funk, visiting some silver mines in Sweden, observed, that, in a clear day, it was as dark as pitch underground in the eye of a pit, at 60 or 70 fathoms deep; whereas, in a cloudy or rainy day, he could even see to read at 106 fathoms deep. Inquiring of the miners, he was informed that this is always the case; and, reflecting upon it, he imagined that it arose from this circumstance, that when the atmosphere is full of clouds, light is reflected from them into the pit in all directions, and that thereby a considerable proportion of the rays are reflected perpendicularly upon the earth; whereas, when the atmosphere is clear, there are no opaque bodies to reflect the light in this manner, at least in a sufficient quantity; and rays from the sun itself can never fall perpendicularly in that country. The other was that of the ingenious Mr Grey, who makes such a figure in the history of electricity. This gentleman took a piece of stiff brown paper, and pricking a small hole in it, he held it at a little distance before him; when, applying a needle to his eye, he was surprised to see the point of it inverted. The nearer the needle was to the hole, the more it was magnified, but the less distinct; and if it was so held, as that its image was near the edge of the hole, its point seemed crooked. From these appearances he concluded, that these small holes, or something in them, produce the effects of concave speculums; and from this circumstance he took the liberty to call them *aerial speculums*.

§ 4. Discoveries concerning the Inflection of Light.

THIS property of light was not discovered till about the middle of the last century. The person who first made the discovery was Father Grimaldi; at least he first published an account of it in his treatise *De lumine, coloribus, et iride*, printed in 1666. Dr Hooke, however, laid claim to the same discovery, though he did not publish his observations till six years after Grimaldi; having probably never seen his performance.

Dr Hooke having made his room completely dark, admitted into it a beam of the sun's light by a very small hole in a brass plate fixed in the window-shutter. This beam spreading itself, formed a cone, the apex of which was in the hole, and the base was on a paper, so placed as to receive it at some distance. In this image of the sun, thus painted on the paper, he observed that the middle was much brighter than the edges, and that there was a kind of dark penumbra about it, of about a 16th part of the diameter of the circle; which penumbra, he says, must be ascribed to a property of light, which he promised to explain.—

Having observed this, at the distance of about two inches from the former he let in another cone of light; and receiving the bases of them, at such a distance from the holes as that the circles intersected each other, he observed that there was not only a penumbra, or darker ring, encompassing the lighter circle, but a manifest dark line, or circle, which appeared even where the limb of the one interfered with that of the other. This appearance is distinctly represented, fig. 6.

Comparing the diameter of this base with its distance from the hole, he found it to be by no means the same as it would have been if it had been formed by straight lines drawn from the extremities of the sun's disk, but varied with the size of the holes, and the distance of the paper.

Struck with this appearance, he proceeded to make farther experiments concerning the nature of light thus transmitted. To give a just idea of which, he held an opaque body BB, fig. 7. so as to intercept the light that entered at a hole in the window-shutter O, and was received on the screen AP. In these circumstances, he observed, that the shadow of the opaque body (which was a round piece of wood, not bright or polished) was all over somewhat enlightened, but more especially towards the edge. Some persons who were present, imagining that this light within the shadow might be produced by some kind of reflection from the side of this opaque body, on account of its roundness; and others supposing it might proceed from some reflection from the sides of the hole in the piece of brass through which the light was admitted into the room; to obviate both these objections, he admitted the light through a hole burnt in a piece of pasteboard, and intercepted it with a razor which had a very sharp edge; but still the appearances were the very same as before: so that, upon the whole, he concluded that they were occasioned by a new property of light, different from any that had been observed by preceding writers.

He farther diversified this experiment, by placing the razor so as to divide the cone of light into two parts, the hole in the shutter remaining as before, and placing the paper so as that none of the enlightened part of the circle fell upon it, but only the shadow of the razor; and, to his great surprise, he observed what he calls a *very brisk and visible radiation* striking down upon the paper, of the same breadth with the diameter of the lucid circle; and this radiation always struck perpendicularly from the line of shadow, and, like the tail of a comet, extended more than 10 times, and probably more than 100 times the breadth of the remaining part of the circle: nay, as far as he could find, by many trials, the light from the edge struck downwards into the shadow very near to a quadrant, though the greater were the deflections of this new light from the direct radiations of the cone, the more faint they were.

Observing this appearance with more attention, he found, wherever there was a part of the interposed body higher than the rest, that, opposite to it, the radiation of light into the shadow was brighter, as in the figure; and wherever there was a notch or gap in it, there would be a dark stroke in the half-enlightened shadow. From all these appearances, he concluded, that they were

Plate
CCCLII.

were to be ascribed to a new property of light, whereby it is deflected from straight lines, contrary to what had been before asserted by optical writers.

It does not appear, however, that our philosopher ever prosecuted this experiment to any purpose; as all that we find of his on the subject of light, after this time, are some crude thoughts which he read at a meeting of the Royal Society, on the 18th of March 1675; which, however, as they are only short hints, we shall copy.

They consist of eight articles; and, as he thought, contained an account of several properties of light that had not been noticed before. There is a deflection of light, differing both from reflection and refraction, and seeming to depend on the unequal density of the constituent parts of the ray, whereby the light is dispersed from the place of condensation, and rarified, or gradually diverged into a quadrant. 2. This deflection is made towards the superficies of the opaque body perpendicularly. 3. Those parts of the diverged radiations which are deflected by the greatest angle from the straight or direct radiations are the faintest, and those that are deflected by the least angles are the strongest. 4. Rays cutting each other in one common foramen do not make the angles at the vertex equal. 5. Colours may be made without refraction. 6. The diameter of the sun cannot be truly taken with common sights. 7. The same rays of light, falling upon the same point of an object, will turn into all sorts of colours, by the various inclinations of the object. 8. Colours begin to appear when two pulses of light are blended so well, and so near together, that the sense takes them for one.

49
Grimaldi's
discoveries.
Plate
CCCLII.

We shall now proceed to the discoveries of Father Grimaldi. Having introduced a ray of light, through a very small hole, AB, fig. 8. into a darkened room, he observed that the light was diffused in the form of a cone, the base of which was CD; and that if any opaque body, FE, was placed in this cone of light, at a considerable distance from the hole, and the shadow was received upon a piece of white paper, the boundaries of it were not confined within GH, or the penumbra IL, occasioned by the light proceeding from different parts of the aperture, and of the disk of the sun, but extended to MN; at which he was very much surprised, suspecting, and finding by calculation, that it was considerably broader than it could have been made by rays passing in right lines by the edges of the object.

But the most remarkable circumstance in this appearance was, that upon the lucid part of the base, CM and ND, streaks of coloured light were plainly distinguished, each being terminated by blue on the side next to the shadow, and by red on the other; and though these coloured streaks depended, in some measure, on the size of the aperture AB, because they could not be made to appear if it was large, yet he found that they were not limited either by it, or by the diameter of the sun's disk.

He farther observed, that these coloured streaks were not all of the same breadth, but grew narrower as they receded from the shadow, and were each of them broader the farther the shadow was received from the opaque body, and also the more obliquely the paper

on which they were received was held with respect to it. He never observed more than three of these streaks.

To give a clearer idea of these coloured streaks, he drew the representation of them, exhibited in fig. 9. in which NMO represents the broadest and most luminous streak, next to the dark shadow X. In the space in which M is placed there was no distinction of colour, but the space NN was blue, and the space OO, on the other side of it, was red. The second streak, QPR, was narrower than the former; and of the three parts of which it consisted, the space P had no particular colour, but QQ was a faint blue, and RR a faint red. The third streak, TSV, was exactly similar to the two others, but narrower than either of them, and the colours still fainter.

These coloured streaks he observed to lie parallel to the shadow of the opaque body; but when it was of an angular form, they did not make the same acute angles, but were bent into a curve, the outermost being rounder than those that were next the shadow, as is represented in fig. 10. If it was an inward angle, as DCH, the coloured streaks, parallel to each other of the two sides, crossed without obliterating one another; only the colours were thereby rendered either more intense or mixed.

The light that formed these coloured streaks, the reader will perceive, must have been bent from the body; but this attentive observer has likewise given an account of other appearances, which must have been produced by the light bending towards the body. For within the shadow itself he sometimes perceived coloured streaks, similar to those above-mentioned on the outside of the shadow. Sometimes he saw more of them, and sometimes fewer; but for this purpose a very strong light was requisite, and the opaque body was obliged to be long, and of a moderate breadth; which, he says, is easily found by experience. A hair, for instance, or a fine needle, did not answer so well as a thin and narrow plate; and the streaks were most distinguishable when the shadow was taken at the greatest distance; but then the light grew fainter in the same proportion.

The number of these streaks within the shadow was greater in proportion to the breadth of the plate. They were at least two, and sometimes four, if a thicker rod were made use of. But, with the same plate or rod, more or fewer streaks appeared, in proportion to the distance at which the shadow was received; but they were broader when they were few, and narrower when there were more of them; and they were all much more distinct when the paper was held obliquely.

These coloured streaks within the shadow, like those on the outside of it, were bent in an arch, round the acute angles of the shadow, as they are represented in fig. 11. At this angle also, as at D, other shorter lucid streaks were visible, bent in the form of a plume, as they are drawn betwixt D and C, each bending round and meeting again in D. These angular streaks appeared, though the plate or rod was not wholly immersed in the beam of light, but the angle of it only; and there were more or fewer in number in proportion to the breadth of the rod or plate. If the plate

or

or red was very thin, the coloured streaks within the shadow might be seen to bend round from the opposite sides, and meet one another, as at B. A only represents a section of the figure, and not a proper termination of the shadow, and the streaks within each side of it. The coloured streaks without the shadow, he also observes, bend round it in the same manner.

Our author acknowledges, that he omits several observations of less consequence, which cannot but occur to any person who shall make the experiment: and he says, that he was not able to give a perfectly clear idea of what he has attempted to describe, nor does he think it in the power of words to do it.

Plate
CCCLII.

In order to obtain the more satisfactory proof that rays of light do not always proceed in straight lines, but really bend, in passing by the edges of bodies, he diversified the first of the above mentioned experiments in the following manner. He admitted a beam of light, by a very small aperture, into a darkened room, as before; and, at a great distance from it, he fixed a plate EF, fig. 12. with a small aperture, GH, which admitted only a part of the beam of light, and found, that when the light transmitted through this plate was received at some distance upon a white paper, the base IK was considerably larger than it could possibly have been made by rays issuing in right lines through the two apertures, as the other straight lines drawn close to their edges plainly demonstrate.

That those who choose to repeat these experiments may not be disappointed in their expectations from them, our author gives the following more particular instructions. The sun's light must be very intense, and the apertures through which it is transmitted very narrow, particularly the first, CD, and the white paper, IK, on which it is received, must be at a considerable distance from the hole GH; otherwise it will not much exceed NO, which would be the breadth of the beam of light proceeding in straight lines. He generally made the aperture CD $\frac{4}{100}$ or $\frac{5}{100}$ part of an ancient Roman foot, and the second aperture, GH, $\frac{2.5}{100}$ or $\frac{3.0}{100}$; and the distances DG and GN were, at least, 12 such feet. The observation was made in the summer time, when the atmosphere was free from all vapours, and about mid-day.

F. Grimaldi also made the same experiment that has been recited from Dr Hooke, in which two beams of light, entering a darkened room by two small apertures near to one another, projected cones of light, which, at a certain distance, in part coincided; and he particularly observed that the dark boundaries of each of them were visible within the lucid ground of the other.

50
Observa-
tion of De-
chales.

To these discoveries of Grimaldi, we shall subjoin an additional observation of Dechales; who took notice, that if small scratches be made in any piece of polished metal, and it be exposed to the beams of the sun in a darkened room, it will reflect the rays streaked with colours in the direction of the scratches; as will appear if the reflected light be received upon a piece of white paper. That these colours are not produced by refraction, he says, is manifest; for that, if the scratches be made upon glass, the effect will be the same; and in this case, if the light had been

refracted at the surface of the glass, it would have been transmitted through it. From these, and many other observations, he concludes that colour does not depend upon the refraction of light only, nor upon a variety of other circumstances, which he particularly enumerates, and the effects of which he discusses, but upon the intensity of the light only.

We shall here give an account of a phenomenon⁵¹ of vision observed by M. De la Hire, because the⁵² subject of this section, viz. the *inflection of light*, seems to supply the true solution of it, though the author himself thought otherwise. It is observable, he says, that when we look at a candle, or any luminous body, with our eyes nearly shut, rays of light are extended from it, in several directions, to a considerable distance, like the tails of comets. This appearance exercised the sagacity of Descartes and Rohault, as well as of our author; but all three seem to have been mistaken with respect to it. Descartes ascribed this effect to certain wrinkles in the surface of the humours of the eye. Rohault says, that when the eye-lids are nearly closed, the edges of them act like convex lenses. But our author says, that the moisture on the surface of the eye, adhering partly to the eye itself, and partly to the edge of the eye-lid, makes a concave mirror, and so disperses the rays at their entrance into the eye. But the true reason seems to be, that the light passing among the eye-lashes, in this situation of the eye, is inflected by its near approach to them, and therefore enters the eye in a great variety of directions. The two former of these opinions are particularly stated and objected to by our author.

The experiments of Father Grimaldi and Dr Hooke⁵³ were not only repeated with the greatest care by Sir Isaac Newton, but carried much farther than they had⁵⁴ thought of. So little use had been made of Grimaldi's observations, that all philosophers before Newton had ascribed the broad shadows, and even the fringes of light which he described, to the ordinary refraction of the air: but we shall see them placed in a very different point of view by our author.

He made in a piece of lead a small hole with a pin, the breadth of which was the 42d part of an inch. Through this hole he let into his darkened chamber a beam of the sun's light; and found, that the shadows of hairs, and other slender substances placed in it, were considerably broader than they would have been if the rays of light had passed by those bodies in right lines. He therefore concluded, that they must have passed as they are represented in fig. 1. in which X represents a section of the hair, and AD, BE, &c. rays of light passing by at different distances, and then falling upon the wall GQ. Since, when the paper which receives the rays is at a great distance from the hair, the shadow is broad, it must follow, as he observes, that the hair acts upon the rays of light at some considerable distance from it, the action being strongest on those rays which are at the least distance, and growing weaker and weaker on those which are farther off, as is represented in this figure; and from hence it comes to pass that the shadow of the hair is much broader in proportion to the distance of the paper from the hair when it is nearer than when it is at a great distance.

He found, that it was not material whether the hair was surrounded with air, or with any other pellucid

Plate
CCCLIII.

substance; for he wetted a polished plate of glass, and laid the hair in the water upon the glass, and then laying another polished plate of glass upon it, so that the water might fill up the space between the glasses, and holding them in the beam of light, he found the shadow at the same distances was as big as before. Also the shadows of scratches made in polished plates of glass, and the veins in the glass, cast the like broad shadows: so that this breadth of shadow must proceed from some other cause than the refraction of the air.

The shadows of all bodies, metals, stones, glass, wood, horn, ice, &c. in this light were bordered with three parallel fringes, or bands of coloured light, of which that which was contiguous to the shadow was the broadest and most luminous, while that which was the most remote was the narrowest, and so faint as not easily to be visible. It was difficult to distinguish these colours, unless when the light fell very obliquely upon a smooth paper, or some other smooth white body, so as to make them appear much broader than they would otherwise have done; but in these circumstances the colours were plainly visible, and in the following order. The first or innermost fringe was violet, and deep blue next the shadow, light blue, green, and yellow in the middle, and red without. The second fringe was almost contiguous to the first, and the third to the second; and both were blue within, and yellow and red without; but their colours were very faint, especially those of the third. The colours, therefore, proceeded in the following order from the shadow; violet, indigo, pale blue, green, yellow, red; blue, yellow, red; pale blue, pale yellow, and red. The shadows made by scratches and bubbles in polished plates of glass were bordered with the like fringes of coloured light.

He also observes, that by looking on the sun through a feather, or black ribbon, held close to the eye, several rainbows will appear, the shadows which the fibres or threads cast on the retina being bordered with the like fringes of colours.

Measuring these fringes and their intervals with the greatest accuracy, he found the former to be in the progression of the numbers $1, \sqrt{\frac{1}{2}}, \sqrt{\frac{1}{3}},$ and their intervals to be in the same progression with them, that is, the fringes and their intervals together to be in continual progression of the numbers $1, \sqrt{\frac{1}{2}}, \sqrt{\frac{1}{3}}, \sqrt{\frac{1}{4}}, \sqrt{\frac{1}{5}},$ or thereabouts. And these proportions held the same very nearly at all distances from the hair, the dark intervals of the fringes being as broad in proportion to the breadth of the fringes at their first appearance as afterwards, at great distances from the hair, though not so dark and distinct.

In the next observation of our author, we find a very remarkable and curious appearance, which we should hardly have expected from the circumstances, though it is pretty similar to one that was noticed by Dr Hooke. The sun shining into his darkened chamber, through a hole $\frac{1}{4}$ of an inch broad, he placed, at the distance of two or three feet from the hole, a sheet of pasteboard, black on both sides; and in the middle of it he had made a hole about $\frac{1}{4}$ of an inch square, for the light to pass through; and behind the hole he fastened to the pasteboard the blade of a sharp knife, to intercept some part of the light which passed through

N^o 247.

the hole. The planes of the pasteboard and blade of the knife were parallel to one another, and perpendicular to the rays; and when they were so placed that none of the light fell on the pasteboard, but all of it passed through the hole to the knife, and there part of it fell upon the blade of the knife, and part of it passed by its edge, he let that part of the light which passed by fall on a white paper, 2 or 3 feet beyond the knife, and there saw two streams of faint light shoot out both ways from the beam of light into the shadow, like the tails of comets. But because the sun's direct light, by its brightness upon the paper, obscured these faint streams, so that he could scarce see them, he made a little hole in the midst of the paper for that light to pass through and fall on a black cloth behind it; and then he saw the two streams plainly. They were like one another, and pretty nearly equal in length, breadth, and quantity of light. Their light, at that end which was next to the sun's direct light, was pretty strong for the space of about $\frac{1}{2}$ of an inch, or $\frac{1}{3}$ of an inch, and decreased gradually till it became insensible.

The whole length of either of these streams, measured upon the paper, at the distance of 3 feet from the knife, was about 6 or 8 inches; so that it subtended an angle, at the edge of the knife, of about 10 or 12, or at most 14, degrees. Yet sometimes he thought he saw it shoot 3 or 4 degrees farther; but with a light so very faint, that he could hardly perceive it. This light he suspected might, in part at least, arise from some other cause than the two streams. For, placing his eye in that light, beyond the end of that stream which was behind the knife, and looking towards the knife, he could see a line of light upon its edge; and that not only when his eye was in the line of the streams, but also when it was out of that line, either towards the point of the knife, or towards the handle. This line of light appeared contiguous to the edge of the knife, and was narrower than the light of the innermost fringe, and narrowest when his eye was farthest from the direct light; and therefore seemed to pass between the light of that fringe and the edge of the knife; and that which passed nearest the edge seemed to be most bent, though not all of it.

He then placed another knife by the former, so that their edges might be parallel, and look towards one another, and that the beam of light might fall upon both the knives, and some part of it pass between their edges. In this situation he observed, that when the distance of their edges was about the 400th part of an inch, the stream divided in the middle, and left a shadow between the two parts. This shadow was so black and dark, that all the light which passed between the knives seemed to be bent and turned aside to the one hand or the other; and as the knives still approached one another, the shadow grew broader and the streams shorter next to it, till, upon the contact of the knives, all the light vanished.

From this experiment our author concludes, that the light which is least bent, and which goes to the inward ends of the streams, passes by the edges of the knives at the greatest distance; and this distance, when the shadow began to appear between the streams, was about the 800th part of an inch; and the light which passed by the edges of the knives at distances still less

and

Fig. 1.

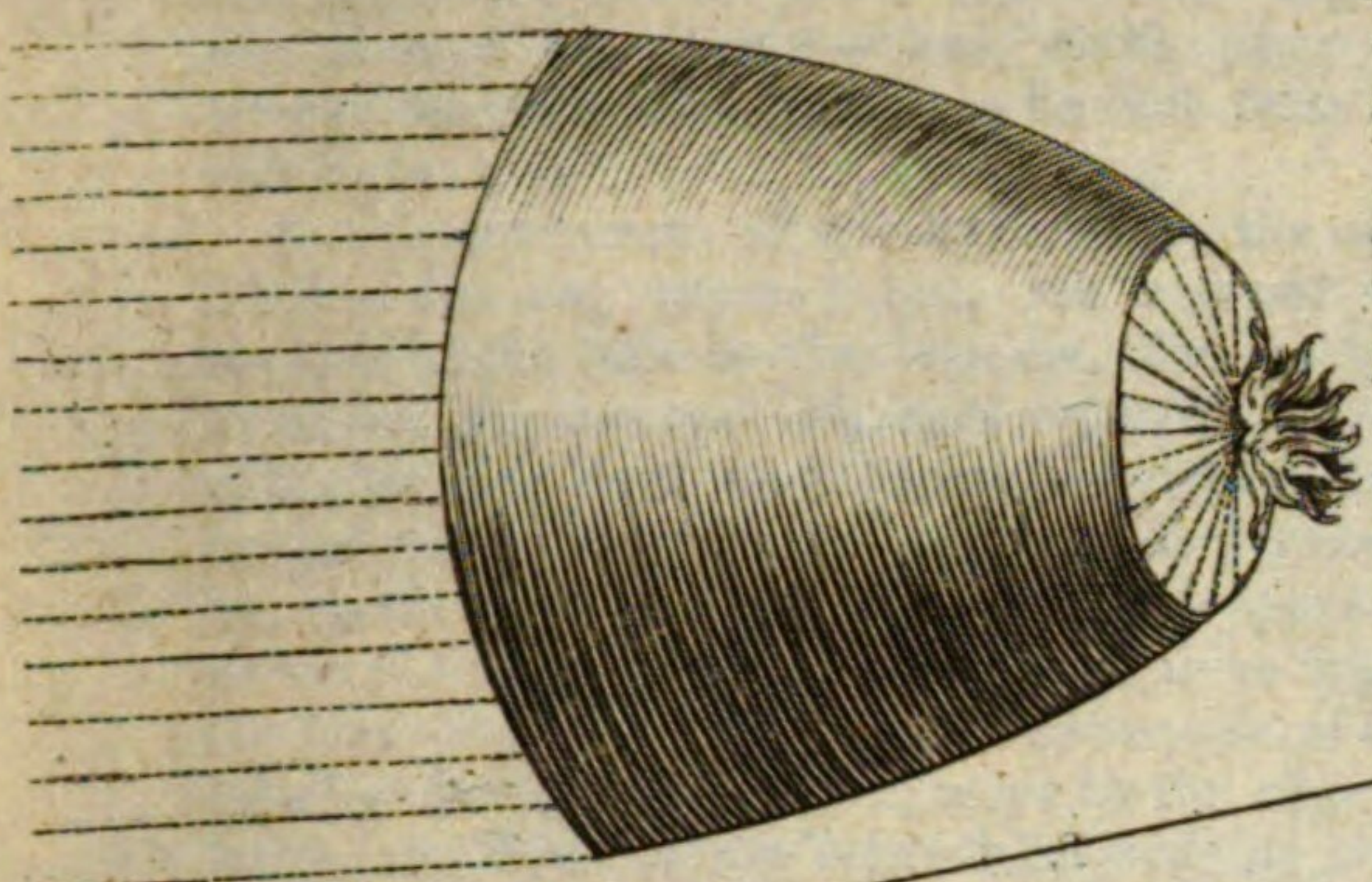


Fig. 2.

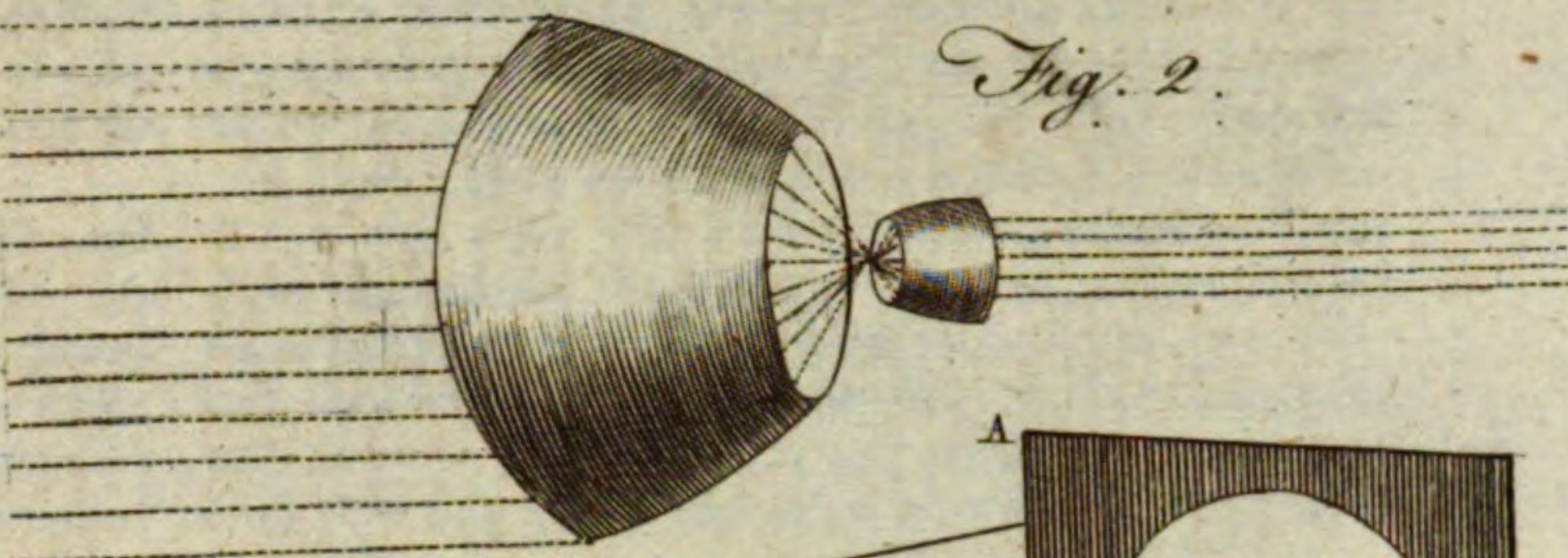


Fig. 7.

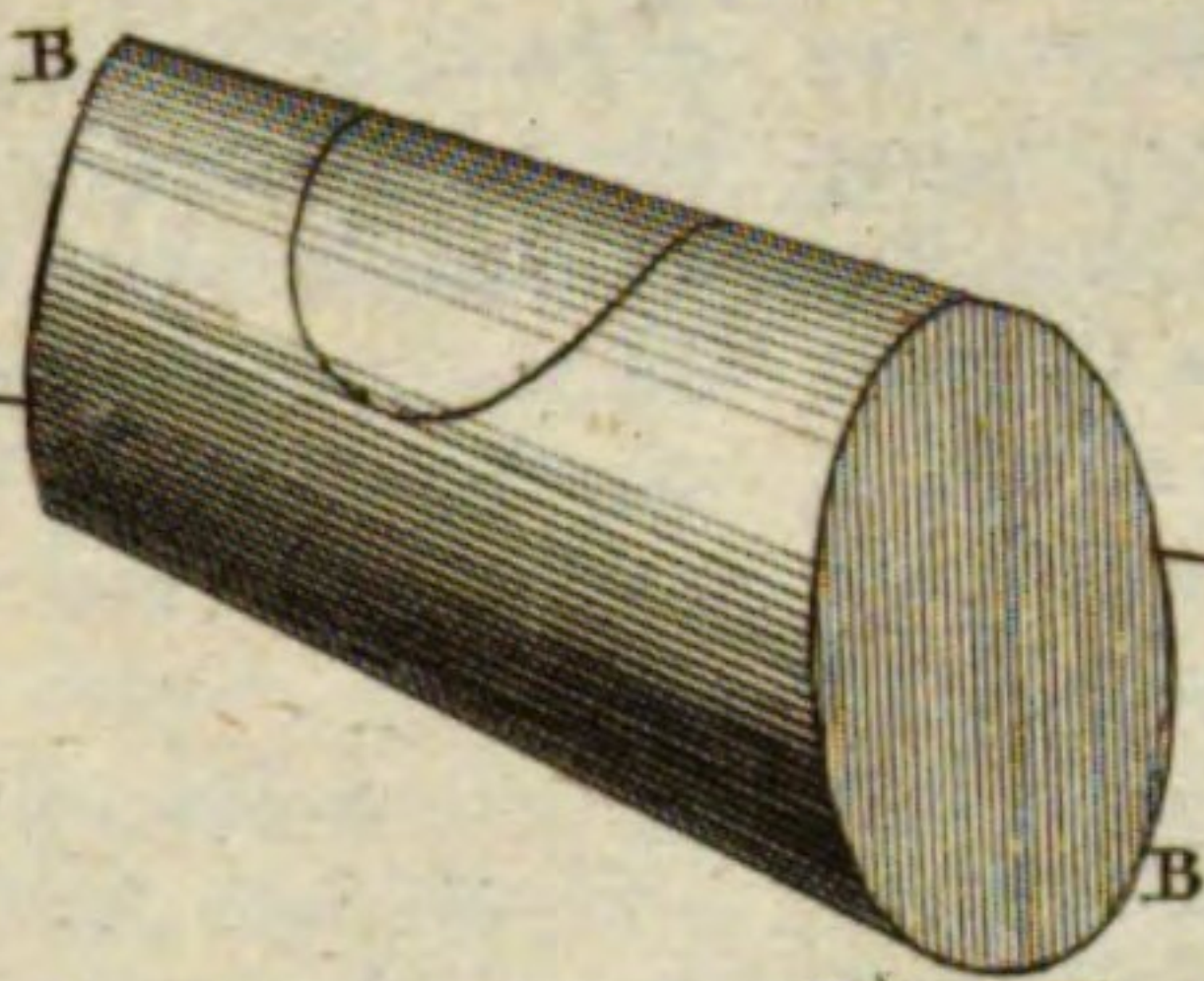


Fig. 5.

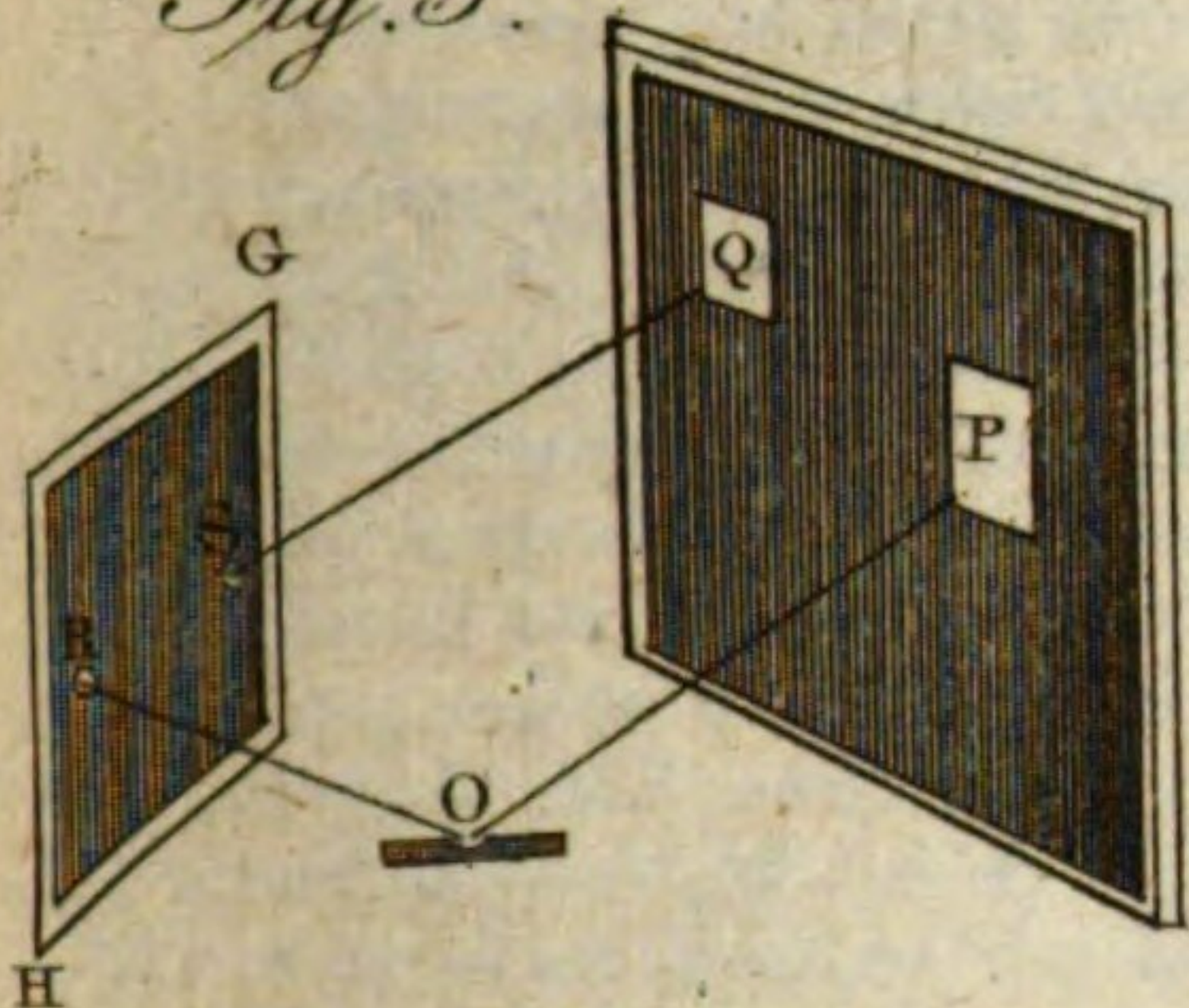


Fig. 10.

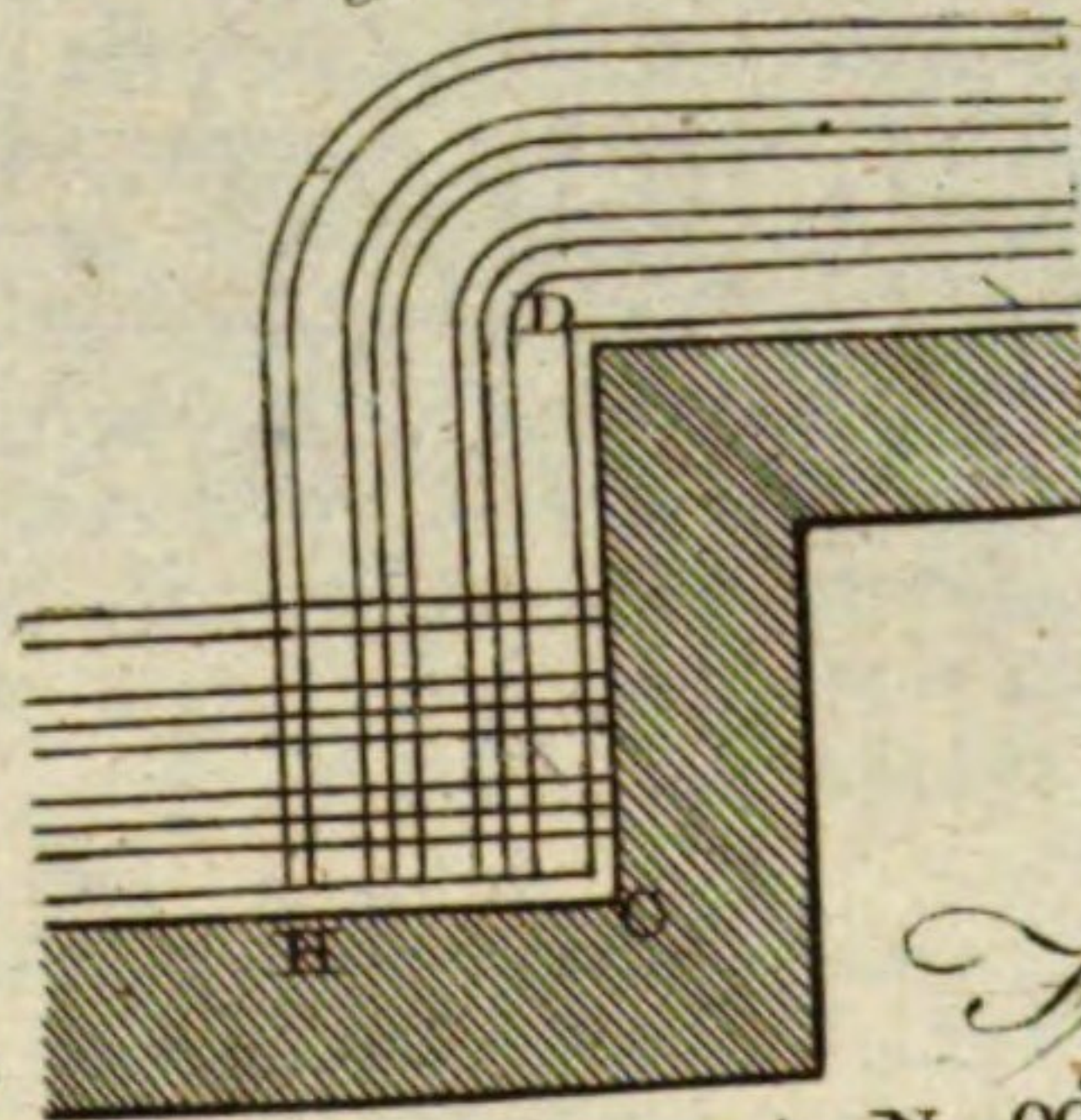


Fig. 4.

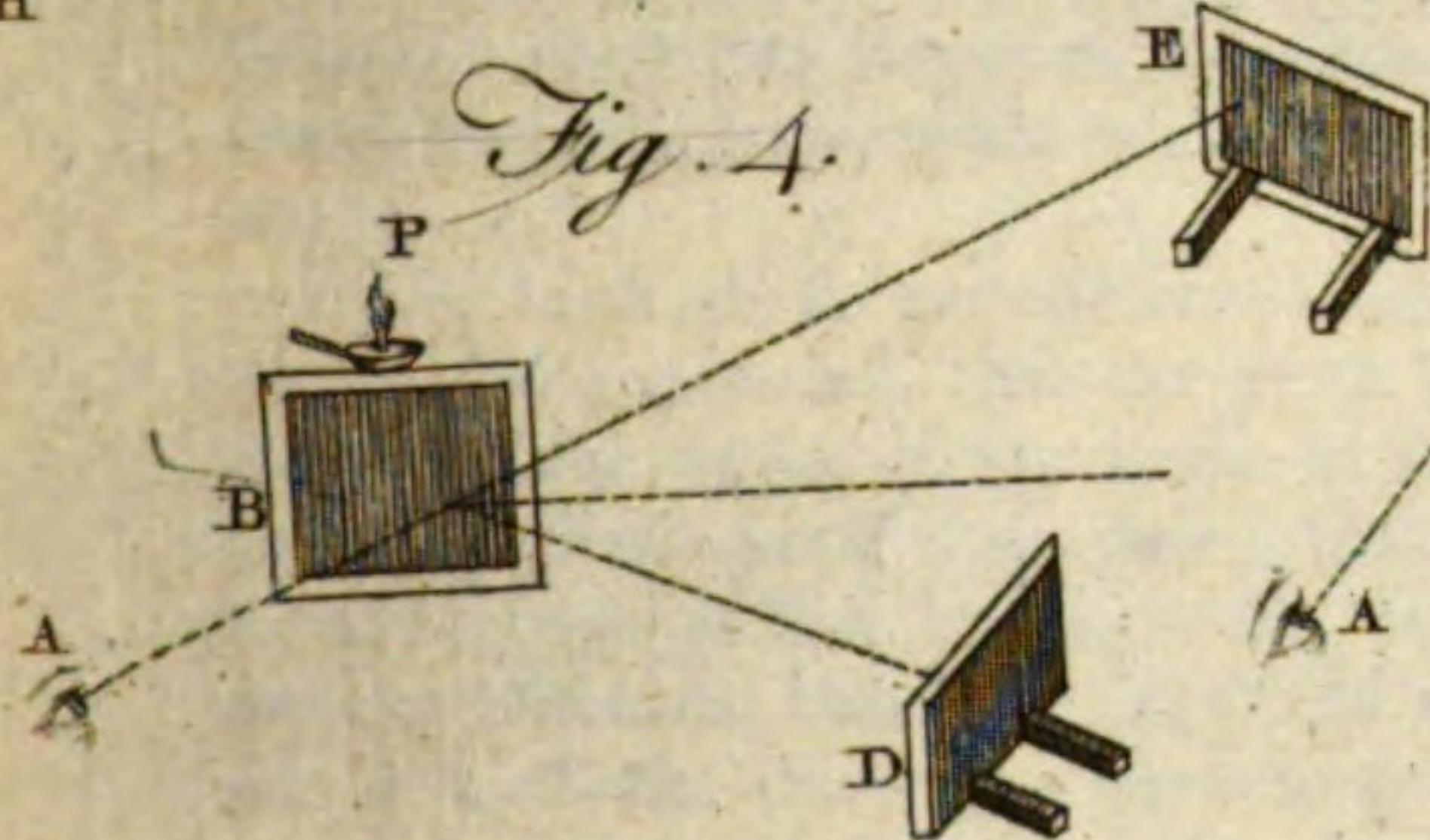


Fig. 3.

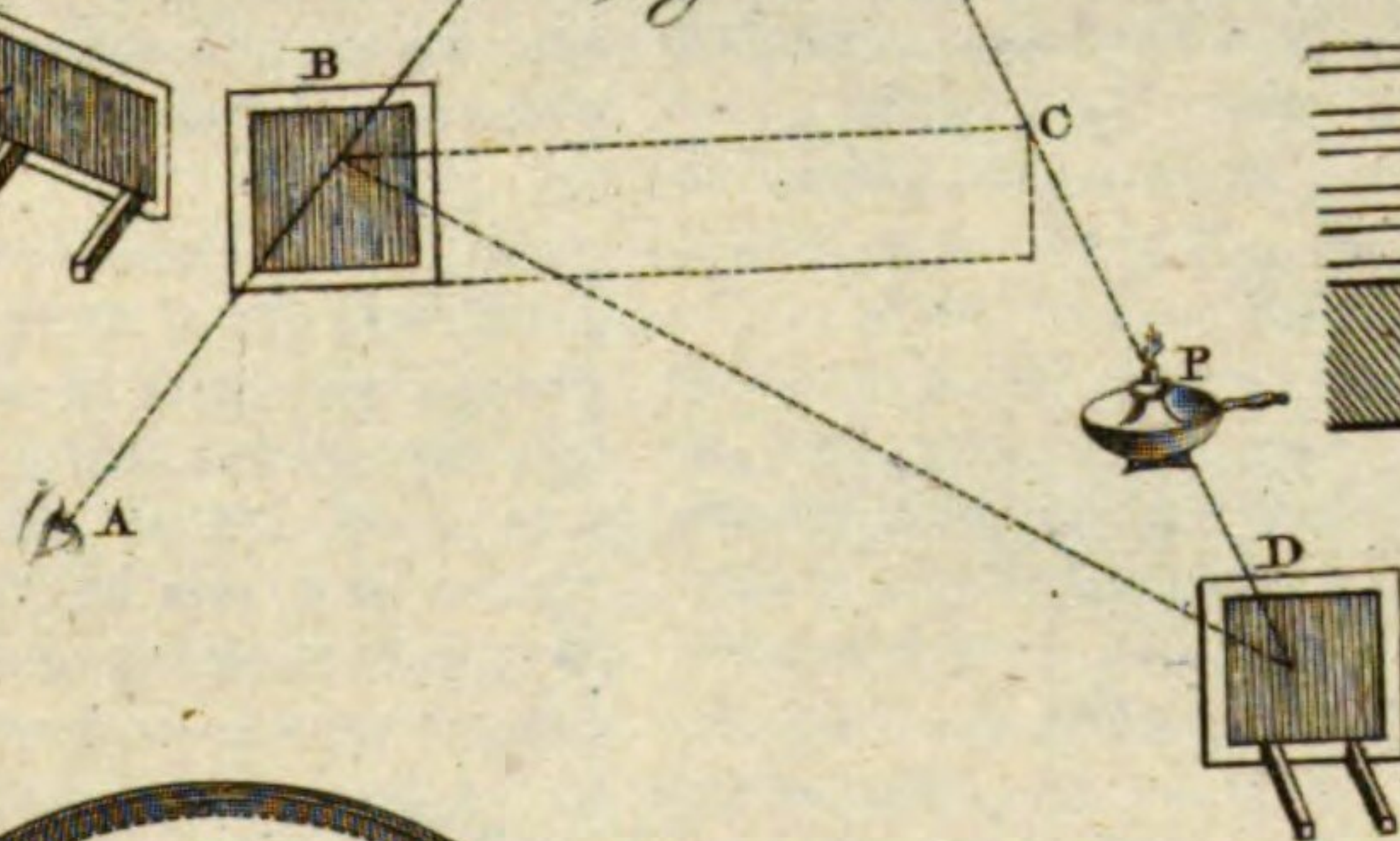


Fig. 9.

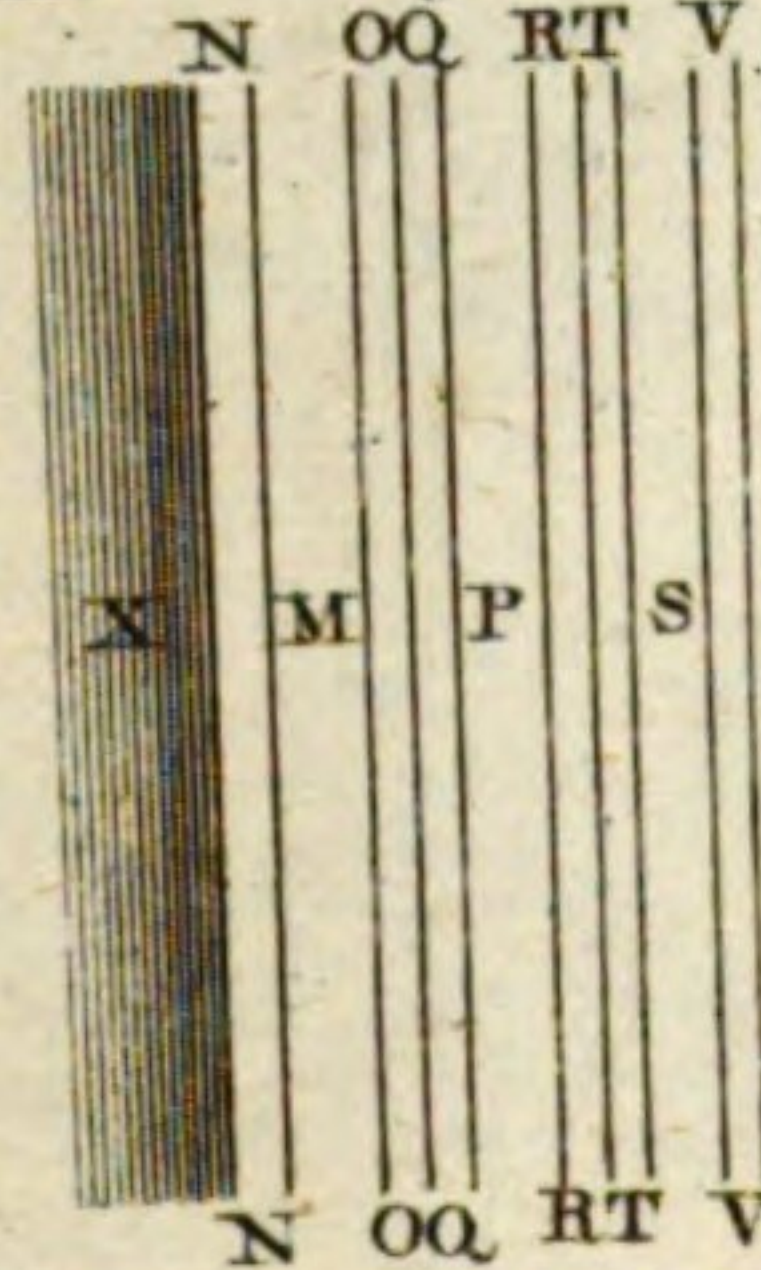


Fig. 6.

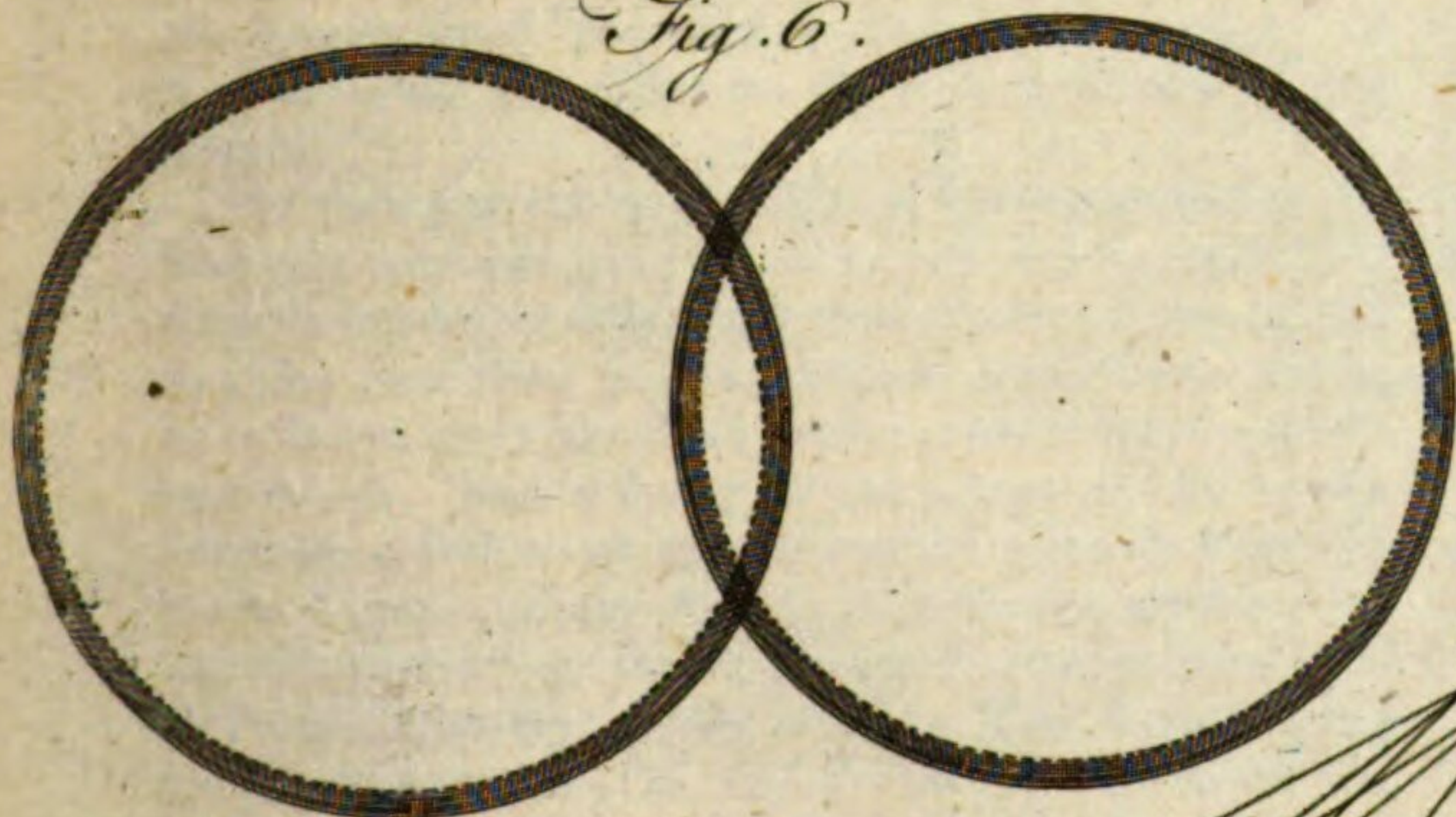


Fig. 11.

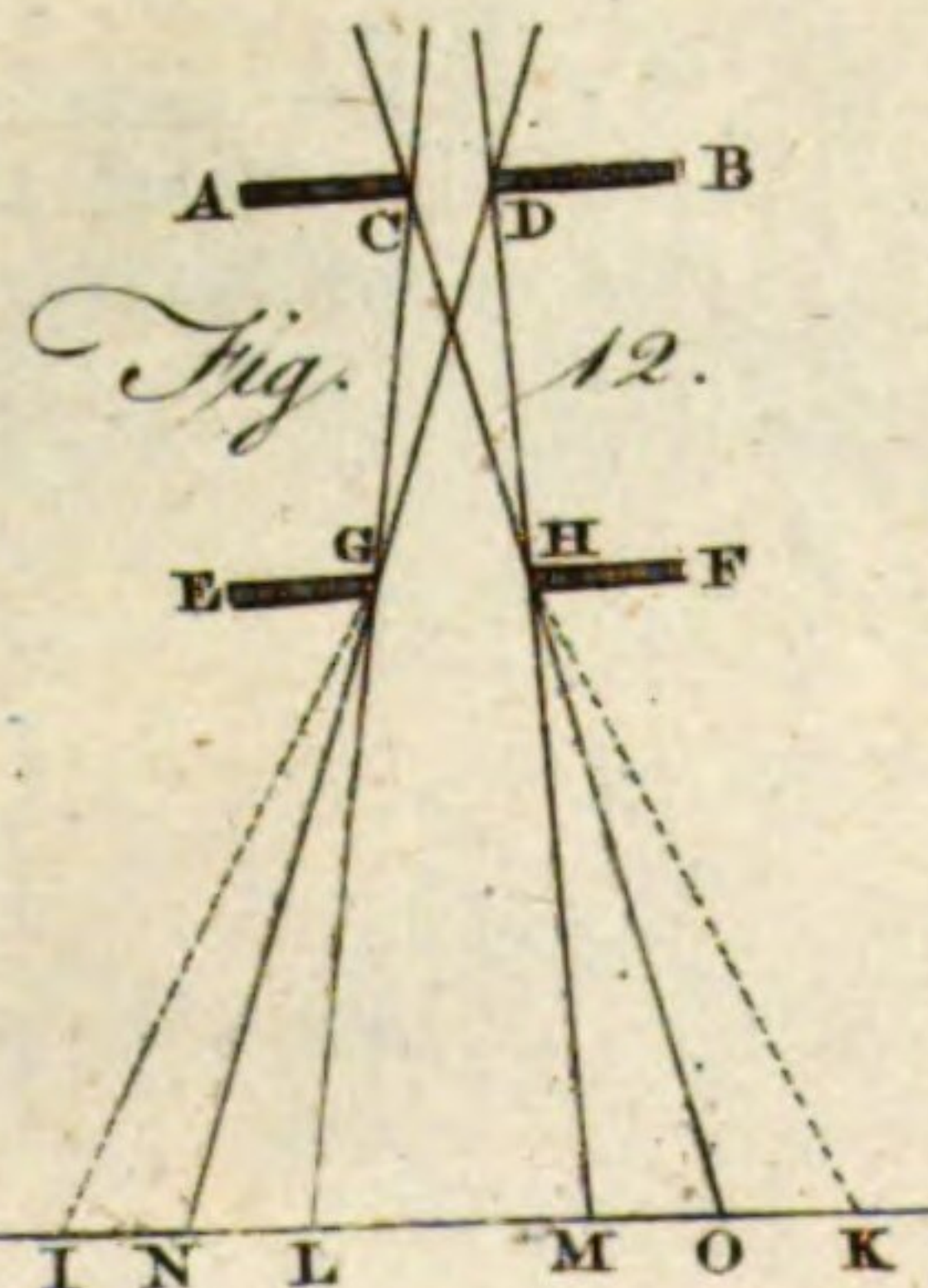
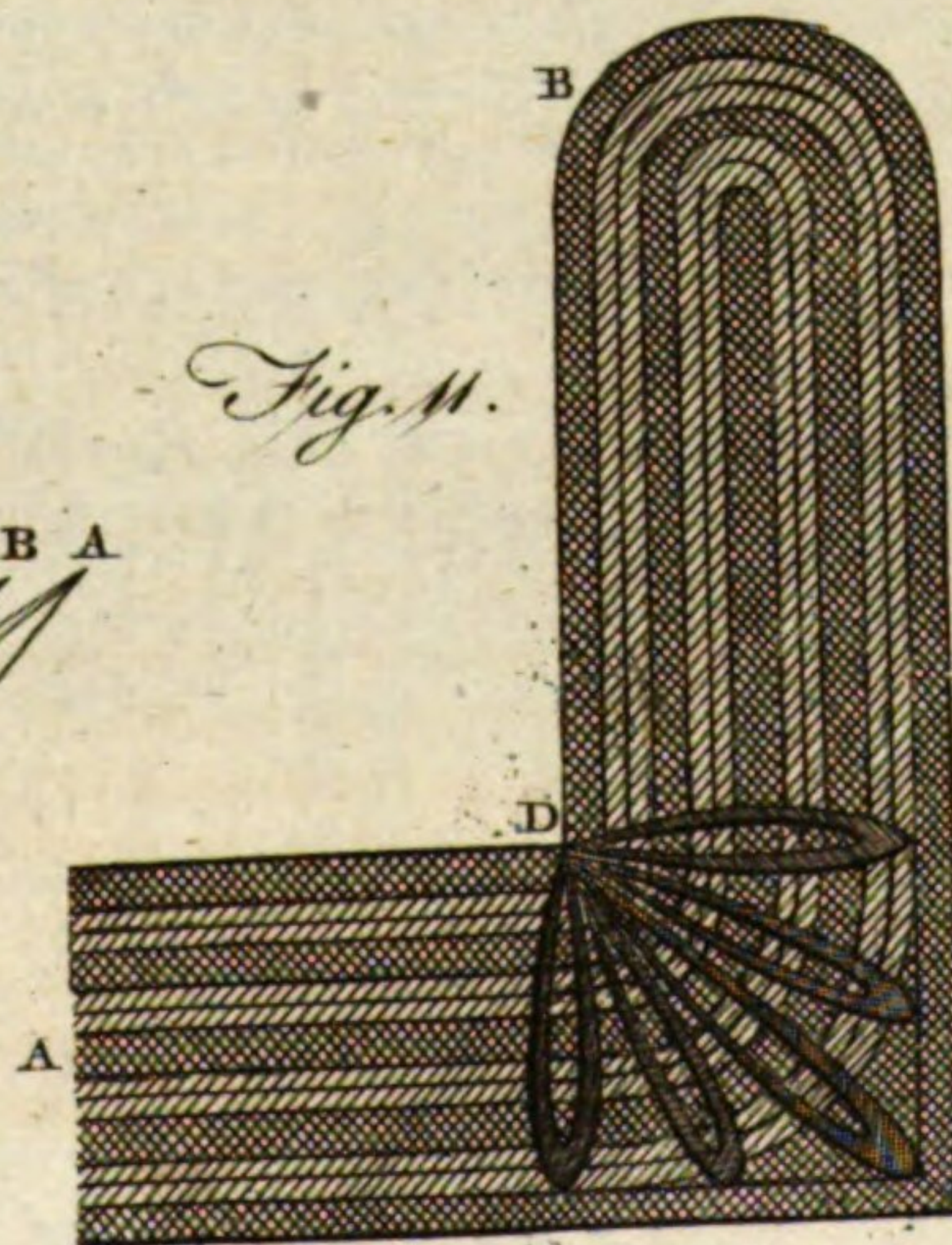
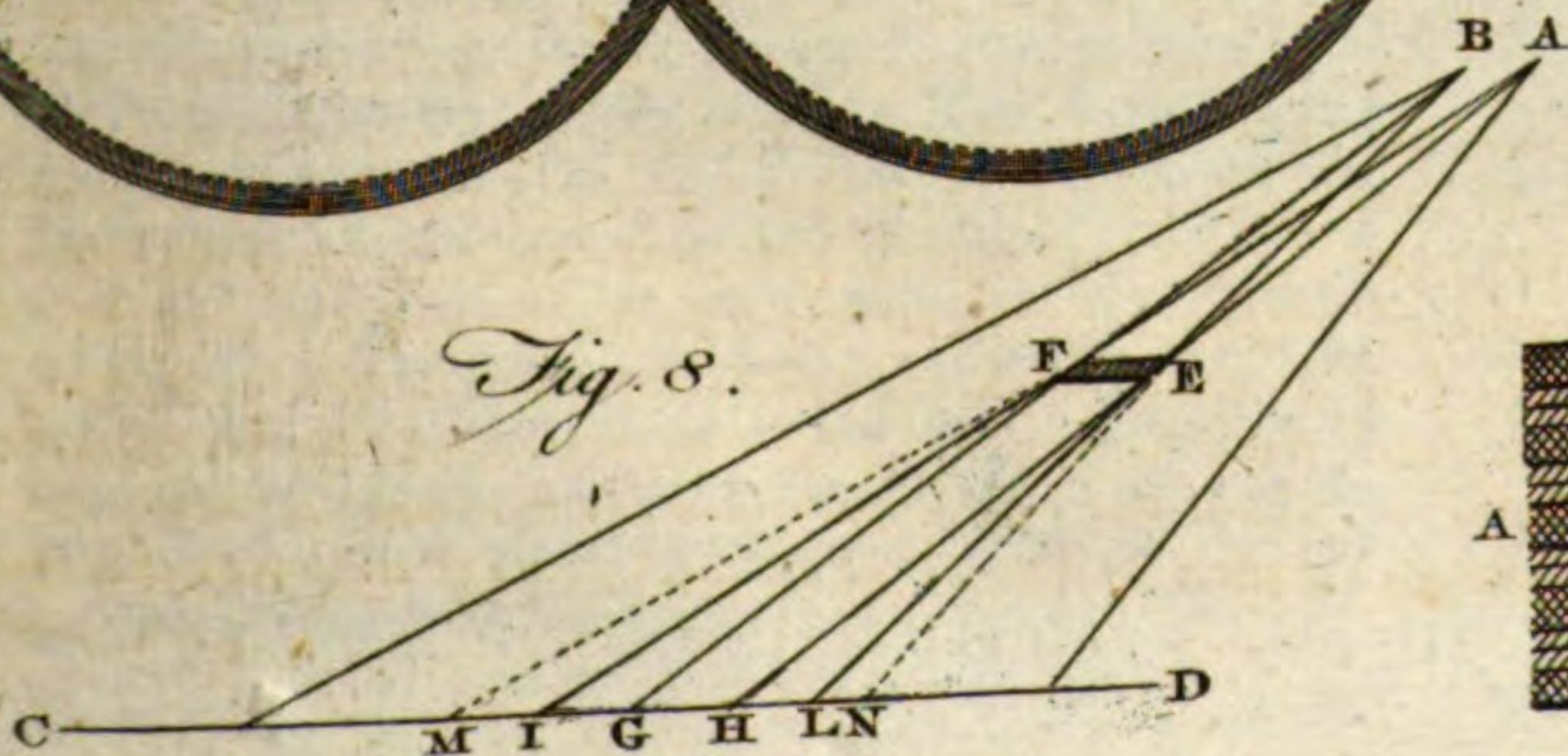
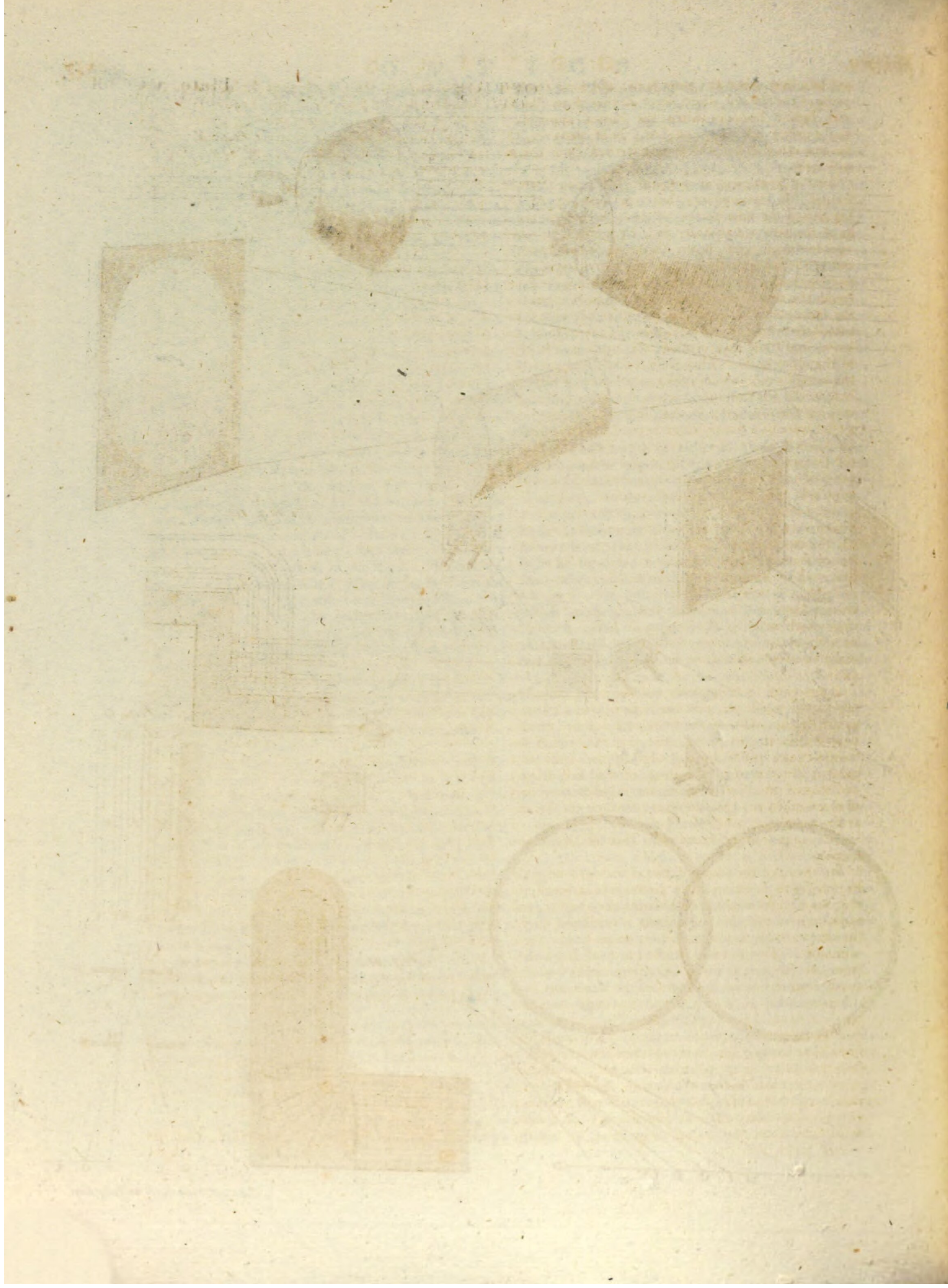


Fig. 8.





and less, was more and more faint, and went to those parts of the streams which were farther from the direct light; because, when the knives approached one another till they touched, those parts of the streams vanished last which were farthest from the direct light.

In the experiment of one knife only, the coloured fringes did not appear; but, on account of the breadth of the hole in the window, became so broad as to run into one another, and, by joining, to make one continual light in the beginning of the streams; but in the last experiment, as the knives approached one another, a little before the shadow appeared between the two streams, the fringes began to appear on the inner ends of the streams, on either side of the direct light; three on one side, made by the edge of one knife, and three on the other side, made by the edge of the other knife. They were the most distinct when the knives were placed at the greatest distance from the hole in the window, and became still more distinct by making the hole less; so that he could sometimes see a faint trace of a fourth fringe beyond the three above-mentioned: and as the knives approached one another, the fringes grew more distinct and larger, till they vanished; the outermost vanishing first, and the innermost last. After they were all vanished, and the line of light which was in the middle between them was grown very broad, extending itself on both sides into the streams of light described before, the above-mentioned shadow began to appear in the middle of this line, and to divide it along the middle into two lines of light, and increased till all the light vanished. This enlargement of the fringes was so great, that the rays which went to the innermost fringe seemed to be bent about 20 times more when the fringe was ready to vanish, than when one of the knives was taken away.

From both these experiments compared together, our author concluded, that the light of the first fringe passed by the edge of the knife at a distance greater than the 800th part of an inch; that the light of the second fringe passed by the edge of the knife at a greater distance than the light of the first fringe, and that of the third at a greater distance than that of the second; and that the light of which the streams above-mentioned consisted, passed by the edges of the knives at less distances than that of any of the fringes.

He then got the edges of two knives ground truly straight, and pricking their points into a board, so that their edges might look towards one another, and meeting near their points, contain a rectilinear angle, he fastened their handles together, to make the angle invariable. The distance of the edges of the knives from one another, at the distance of 4 inches from the angular point, where the edges of the knives met, was the 8th part of an inch; so that the angle contained by their edges was about $1^{\circ} 54'$. The knives being thus fixed together, he placed them in a beam of the sun's light let into his darkened chamber, through a hole the 42d part of an inch wide, at the distance of 10 or 13 feet from the hole; and he let the light which passed between their edges fall very obliquely on a smooth white ruler, at the distance of $\frac{1}{2}$ inch, or an inch, from the knives; and there he saw the

fringes made by the two edges of the knives run along the edges of the shadows of the knives, in lines parallel to those edges, without growing sensibly broader, till they met in angles equal to the angle contained by the edges of the knives; and where they met and joined, they ended, without crossing one another. But if the ruler was held at a much greater distance from the knives, the fringes, where they were farther from the place of their meeting, were a little narrower, and they became something broader as they approached nearer to one another, and after they met they crossed one another, and then became much broader than before.

From these observations he concluded, that the distances at which the light composing the fringes passed by the knives were not increased or altered by the approach of the knives, but that the angles in which the rays were there bent were much increased by that approach; and that the knife which was nearest to any ray determined which way the ray should be bent, but that the other knife increased the bending.

When the rays fell very obliquely upon the ruler, at the distance of a third part of an inch from the knives, the dark line between the first and second fringe of the shadow of one knife, and the dark line between the first and second fringe of the shadow of the other knife, met one another, at the distance of the fifth part of an inch from the end of the light which passed between the knives, where their edges met one another; so that the distance of the edges of the knives, at the meeting of the dark lines, was the 160th part of an inch; and one half of that light passed by the edge of one knife, at a distance not greater than the 320th part of an inch, and, falling upon the paper, made the fringes of the shadow of that knife; while the other half passed by the edge of the other knife, at a distance not greater than the 320th part of an inch, and, falling upon the paper, made the fringes of the shadow of the other knife. But if the paper was held at a distance from the knives greater than the third part of an inch, the dark lines above mentioned met at a greater distance than the fifth part of an inch from the end of the light which passed between the knives, at the meeting of their edges; so that the light which fell upon the paper where those dark lines met passed between the knives, where their edges were farther distant than the 160th part of an inch. For at another time, when the two knives were 8 feet and 5 inches from the little hole in the window, the light which fell upon the paper where the above-mentioned dark lines met passed between the knives, where the distance between their edges was, as in the following table, at the distances from the paper there noted.

Distances of the paper from the knives in inches.	Distances between the edges of the knives in millesimal parts of an inch.
1 $\frac{1}{2}$	0,012
3 $\frac{1}{2}$	0,020
8 $\frac{1}{2}$	0,034
32	0,057
96	0,081
131	0,087

From these observations he concluded, that the light

K k

light which makes the fringes upon the paper is not the same light at all distances of the paper from the knives; but that, when the paper is held near the knives, the fringes are made by light which passes by the edges of the knives at a less distance, and is more bent than when the paper is held at a greater distance from the knives.

Plate
CCCLIII.
fig. 2.

When the fringes of the shadows of the knives fell perpendicularly upon the paper, at a great distance from the knives, they were in the form of hyperbolas, their dimensions being as follows. Let CA, CB, represent lines drawn upon the paper, parallel to the edges of the knives; and between which all the light would fall if it suffered no inflection. DE is a right line drawn through C, making the angles ACD, BCE, equal to one another, and terminating all the light which falls upon the paper, from the point where the edges of the knives meet. Then *eis*, *fk t*, and *g l v*, will be three hyperbolical lines, representing the boundaries of the shadow of one of the knives, the dark line between the first and second fringes of that shadow, and the dark line between the second and third fringes of the same shadow. Also *xip*, *ykq*, and *zlr*, will be three other hyperbolical lines, representing the boundaries of the shadow of the other knife, the dark line between the first and second fringes of that shadow, and the dark line between the second and third fringes of the same shadow. These three hyperbolas are similar, and equal to the former three, and cross them in the points *i*, *k*, and *l*; so that the shadows of the knives are terminated, and distinguished from the first luminous fringes, by the lines *eis* and *xip*, till the meeting and crossing of the fringes; and then those lines cross the fringes in the form of dark lines terminating the first luminous fringes on the inside, and distinguishing them from another light, which begins to appear at *i*, and illuminates all the triangular space *ip DE*, comprehended by these dark lines and the right line DE. Of these hyperbolas one asymptote is the line DE, and the other asymptotes are parallel to the lines CA and CB.

The sun shining into his darkened room through the small hole mentioned above, he placed at the hole a prism to refract the light, and to form on the opposite wall the coloured image of the sun; and he found, that the shadows of all bodies held in the coloured light between the prism and the wall, were bordered with fringes of the colour of that light in which they were held; and comparing the fringes made in the several coloured lights, he found, that those made in the red light were the largest, those made in the violet were the least, and those made in the green were of a middle bigness. For the fringes with which the shadow of a man's hair were bordered, being measured cross the shadow, at the distance of six inches from the hair, the distance between the middle and most luminous part of the first or innermost fringe on one side of the shadow, and that of the like fringe on the other side of the shadow, was, in the full red light $\frac{1}{37\frac{1}{2}}$ of an inch, and in the full violet $\frac{1}{36}$. The like distance between the middle and most luminous parts of the second fringes, on either side of the shadow, was in the full red light $\frac{1}{22}$, and the violet $\frac{1}{27}$ of an inch; and these distances of the fringes held the same pro-

portion at all distances from the hair, without any sensible variation.

From these observations it was evident, that the rays which made the fringes in the red light, passed by the hair at a greater distance than those which made the like fringes in the violet; so that the hair, in causing these fringes, acted alike upon the red light or least refrangible rays at a greater distance, and upon the violet or most refrangible rays at a less distance; and thereby occasioned fringes of different sizes, without any change in the colour of any sort of light.

It may therefore be concluded, that when the hair in the first observation was held in the white beam of the sun's light, and cast a shadow which was bordered with three fringes of coloured light, those colours arose not from any new modifications impressed upon the rays of light by the hair, but only from the various inflections whereby the several sorts of rays were separated from one another, which before separation, by the mixture of all their colours, composed the white beam of the sun's light; but, when separated, composed lights of the several colours which they are originally disposed to exhibit.

The person whose name we find first upon the list of those who pursued any experiments similar to those of Newton on inflected light is M. Miraldi; whose observations chiefly respect the inflection of light towards other bodies, whereby their shadows are partially illuminated; and many of the circumstances which he noticed relating to it are well worthy of our attention, as the reader will be convinced from the following account of them.

53
Miraldi's
discoveries.

He exposed in the light of the sun a cylinder of wood three feet long, and $6\frac{1}{2}$ lines in diameter; when its shadow, being received upon a paper held close to it, was everywhere equally black and well defined, and continued to be so to the distance of 23 inches from it. At a greater distance the shadow appeared to be of two different densities; for the two extremities of the shadow, in the direction of the length of the cylinder, were terminated by two dark strokes, a little more than a line in breadth. Within these dark lines there was a faint light, equally dispersed through the shadow, which formed an uniform penumbra, much lighter than the dark strokes at the extremity, or than the shadow received near the cylinder. This appearance is represented in Plate CCCLIII. fig. 3.

54
Experiments
concerning the
shadows of
cylinders.

As the cylinder was removed to a greater distance from the paper, the two black lines continued to be nearly of the same breadth, and the same degree of obscurity; but the penumbra in the middle grew lighter, and its breadth diminished, so that the two dark lines at the extremity of the shadow approached one another, till, at the distance of 60 inches, they coincided, and the penumbra in the middle entirely vanished. At a still greater distance a faint penumbra was visible; but it was ill defined, and grew broader as the cylinder was removed farther off, but was sensible at a very great distance.

Besides the black and dark shadow, which the cylinder formed near the opaque body, a narrow and faint penumbra was seen on the outside of the dark shadow. And on the outside of this there was a tract more strongly illuminated than the rest of the paper.

The breadth of the external penumbra increased with the distance of the shadow from the cylinder, and the breadth of the tract of light on the outside of it was also enlarged; but its splendor diminished with the distance.

He repeated these experiments with three other cylinders of different dimensions; and from them all he inferred, that every opaque cylindrical body, exposed to the light of the sun, makes a shadow which is black and dark to the distance of 38 to 45 diameters of the cylinder which forms it; and that, at a greater distance, the middle part begins to be illuminated in the manner described above.

In explaining these appearances, our author supposes that the light which diluted the middle part of the shadow was occasioned by the inflection of the rays, which, bending inwards on their near approach to the body, did at a certain distance enlighten all the shadow, except the edges, which was left undisturbed. At the same time other rays were deflected from the body, and formed a strong light on the outside of the shadow, and which might at the same time contribute to dilute the outer shadow, though he supposed that penumbra to be occasioned principally by that part of the paper not being enlightened, except by a part of the sun's disk only, according to the known principles of optics.

55
Concerning
those of
globes.

The same experiments he made with globes of several diameters; but he found, that, whereas the shadows of the cylinders did not disappear but at the distance of 41 of their diameters, those of the globes were not visible beyond 15 of their diameters; which he thought was owing to the light being inflected on every side of a globe, and consequently in such a quantity as to disperse the shadows sooner than in the case of the cylinders.

In all these cases, the penumbra occasioned by the inflected light began to be visible at a less distance from the body in the stronger light of the sun than in a weaker, on account of the greater quantity of rays inflected in those circumstances.

56
His mistake
concerning
the moon.

Considering the analogy between these experiments and the phenomena of an eclipse of the moon, immersed in the shadow of the earth, he imagined, that part of the light by which she is then visible is inflected light, and not that which is refracted by the atmosphere; though this may be so copious as to efface several of the above-mentioned appearances, occasioned by inflected light only. But this gentleman should have considered, that as no light is inflected but what passes exceedingly near to any body, perhaps so near as the distance of $\frac{1}{40}$ part of an inch, this cause must be altogether inadequate to the effect.

Being sensible that the above-mentioned phenomena of the shadows were caused by inflected light, he was induced to give more particular attention to this remarkable property; and, in order to it, to repeat the experiments of Grimaldi and Sir Isaac Newton in a darkened room. In doing this, he presently observed, that, besides the enlarged shadow of a hair, a fine needle, &c. the bright gleam of light that bordered it, and the three coloured rings next to this enlightened part, when the shadow was at a considerable distance from the hair, the dark central shadow was divided in

the middle by a mixture of light; and that it was not of the same density, except when it was very near the hair.

This new appearance will be seen to be exactly similar to what our philosopher had observed with respect to the shadows in the open day-light above mentioned; but the following observations, which he made with some variation of his apparatus, are much more curious and striking, though they arise from the same cause.

Having placed a bristle, which is thicker than a common hair, in the rays of the sun, admitted into a dark chamber by a small hole, at the distance of nine feet from the hole, it made a shadow, which, being received at five or six feet from the object, he observed to consist of several streaks of light and shade. The middle part was a faint shadow, or rather a kind of penumbra, bordered by a darker shadow, and after that by a narrower penumbra; next to which was a light streak broader than the dark part, and next to the streak of light, the red, violet, and blue colours were seen as in the shadow of the hair.

In the same manner he placed, in the same rays of the sun, several needles of different sizes; but the appearances were so exceedingly various, tho' sufficiently singular, that he does not recite them particularly, but chooses rather to give, at some length, the observations he made on the shadows of two plates, as by that means he could better explain the phenomena of the round bodies.

He exposed in the rays of the sun, admitted by a small hole into a dark chamber, a plate that was two inches long, and a little more than half a line broad. This plate being fixed perpendicularly to the rays, at the distance of nine feet from the hole, a faint light was seen uniformly dispersed over the shadow, when it was received perpendicularly to it, and very near. The shadow of the same plate being received at the distance of two feet and a half, was divided into four very narrow black streaks, separated by small lighter intervals equal to them. The boundaries of this shadow on each side had a penumbra, which was terminated by a very strong light, next to which were the coloured streaks of red, violet, and blue, as before. This is represented in Plate CCCLIII. fig. 4.

57
Experiments
concerning the
shadows of
plates.

The shadow of the same plate, at $4\frac{1}{2}$ feet distance from it, was divided into two black streaks only, the two outermost having disappeared, as in fig. 5.; but these two black streaks which remained were broader than before, and separated by a lighter shade, twice as broad as one of the former black streaks, when the shadow was taken at $2\frac{1}{2}$ feet. This penumbra in the middle had a tinge of red. After the two black streaks there appeared a pretty strong penumbra, terminated by the two streaks of light, which were now broad and splendid, after which followed the coloured streaks.

A second plate, two inches long and a line broad, being placed like the former, 14 feet from the hole by which the rays of the sun were admitted, its shadow being received perpendicularly very near the plate, was illuminated by a faint light, equally dispersed, as in the case of the preceding plate. But being received at the distance of 13 feet from the plate, six small black

Plate
CCCLIII.

freaks began to be visible, as in fig. 6. At 17 feet from the plate, the black streaks were broader, more distinct, and more separated from the streaks that were less dark. At 42 feet from the plate, only two black streaks were seen in the middle of the penumbra, as in fig. 7. This middle penumbra between the two black streaks was tinged with red. Next to the black streaks there always appeared the streaks of light, which were broad, and the coloured streaks next to them.

Receiving the shadow of the same plate at the distance of 72 feet, the appearances were the same as in the former situation, except that the two black streaks were broader, and the interval between them, occupied by the penumbra, was broader also, and tinged with a deeper red.

In the same rays of the sun he placed different plates, and larger than the former, one of them a line and a half, another two lines, another three lines broad, &c. but receiving their shadows upon paper, he could not perceive in them those streaks of faint light which he had observed in the shadows of the small plates, though he received these shadows at the distance of 56 feet. Nothing was seen but a weak light, equally diffused, as in the shadows of the two smallest plates, received very near them. But had his dark chamber been large enough, he did not doubt, but that, at a proper distance, there would have been the same appearances in the shadows of the larger plates as in those of the smallest. For the same reason, he supposed, that, if the shadows of the small needles could have been distinctly viewed very near those bodies, the different streaks of light and shade would have been as visible in them as in those of the small plates; and indeed he did observe the same appearances in the shadows of needles of a middling size.

The streaks of light in these shadows our author ascribed to the rays of light which are inflected at different distances from the bodies; and he imagined that their crossing one another was sufficient to account for the variations observable in them at different distances.

The extraordinary size of the shadows of these small substances M. Maraldi thought to be occasioned by the shadow from the enlightened part of the sky, added to that which was made by the light of the sun, and also to a vortex occasioned by the circulation of the inflected light behind the object; but our readers will probably not think it necessary for us either to produce all his reasons for this hypothesis, or to enter into a refutation of them.

Our author having made the preceding experiments upon single long substances, had the curiosity to place two of them so as to cross one another in a beam of the sun's light. The shadows of two hairs placed in this manner, and received at some distance from them, appeared to be painted reciprocally one upon the other, so that the obscure part of one of them was visible upon the obscure part of the other. The streaks of light also crossed one another, and the coloured streaks did the same.

Having placed a needle and a hair crossing one another, their shadows, at the same distance, exhibited

the same appearances as the shadows of the two hairs, though the shadow of the needle was the stronger.

He also placed in the rays of the sun a bristle and a plate of iron a line thick, so that they crossed one another obliquely; and when their shadows were received at the same distance, the light and dark streaks of the shadow of the bristle were visible so far as the middle of the shadow of the plate on the side of the acute angle, but not on the side of the obtuse angle, whither the bristle or the plate were placed next to the rays. The plate made a shadow sufficiently dark, divided into six black streaks; and these were again divided by as many light ones equal to them; and yet all the streaks belonging to the shadow of the bristle were visible upon it, as in fig. 8. To explain this appearance, he supposed that the rays of the sun glided a little along the bristle, so as to enlighten part of that which was behind the plate. But this seems to be an arbitrary and improbable supposition.

Our philosopher did not fail to expose several small globes in the light of the sun in his dark chamber, and to compare their shadows with those of the long substances, as he had done in the day-light, and the appearances were still similar. It was particularly evident, that there was much more light in the shadows of the globes than in those of the cylinders, not only when they were both of an equal diameter, but when that of the globe was larger than that of the cylinder, and the shadows of both the bodies were received at the same distance. He also observed, that he could perceive no difference of light in the shadows of the plates which were a little more than one line broad, though they were received at the distance of 72 feet; but he could easily see a difference of shades in those of the globes, taken at the same distance, tho' they were $2\frac{1}{2}$ lines in diameter.

In order to explain the colours at the edges of these shadows, he contrived to throw some of the shadows upon others; and the following observations, though they did not enable him to accomplish what he intended, are curious and worth reciting.

Having thrown several of the similar colours upon one another, and thereby produced a tinge more lively than before, he threw the gleam of light, which always intervened between the colours and the darker part of the shadow, upon different parts of other shadows; and observed, that, when it fell upon the exterior penumbra made by another needle, it produced a beautiful sky-blue colour, almost like that which was produced by two blue colours thrown together. When the same gleam of light fell upon the deeper shadow in the middle, it produced a red colour; which seemed to prove, that the reddish colour in the middle of several of the shadows might come from the little light inflected into that place. But here our author seems to have been misled by some false hypothesis concerning colours.

He placed two plates of iron, each three or four lines broad, very near one another, but with a very small interval between them; and having placed them in the rays of the sun, and received their shadows at the distance of 15 or 20 feet from them, he saw no light between them but a continued shadow, in the middle

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Experiments with
a mixture
of coloured
shadows.

middle of which were some streaks of a lively purple, parallel to one another, and separated by other black streaks; but between them there were other streaks, both of a very faint green, and also of a pale yellow. He also informs us, that M. Delisle had observed colours in the streaks of light and shade, which are observable in shadows taken near the bodies.

59 M. Mairan's observations. Among those who followed Sir Isaac Newton in his observations on the inflection of light, we also find the ingenious M. Mairan: but, without attempting the discovery of new facts, he only endeavoured to explain the old ones, by the hypothesis of an atmosphere surrounding all bodies; and consequently making two reflections and refractions of the light that impinges upon them, one at the surface of the atmosphere, and the other at that of the body itself. This atmosphere he supposed to be of a variable density and refractive power, like the air.

60 Discoveries of M. Du Tour. M. Mairan was succeeded by M. Du Tour, who thought the variable atmosphere superfluous, and imagined that he could account for all the phenomena by the help of an atmosphere of an uniform density, and of a less refractive power than the air surrounding all bodies. But what we are most obliged to this gentleman for, is, not his ingenious hypothesis, but the beautiful variety with which he has exhibited the experiments, which will render it much easier for any person to investigate the true causes of them.

Before M. Du Tour gave his attention to this subject, only three fringes had been observed in the colours produced by the inflection of light; but he was accidentally led to observe a greater number of them, and adopted from Grimaldi the following ingenious method of making them all appear very distinct.

Plate CCCLIII. He took a circular board ABED (fig. 9.), 13 inches in diameter, the surface of which was black, except at the edge, where there was a ring of white paper about three lines broad, in order to trace the circumference of a circle, divided into 360 degrees, beginning at the point A, and reckoning 180 degrees on each hand to the point E; B and D being each of them placed at 90 degrees. A slip of parchment three inches broad, and disposed in the form of a hoop, was fastened round the board, and pierced at the point E with a square hole, each side being four or five lines, in order to introduce a ray of the sun's light. Lastly, in the centre of the board C, and perpendicular to it, he fixed a pin about $\frac{1}{4}$ of a line in diameter.

This hoop being so disposed, that a ray of light entering the dark chamber, through a vertical cleft of two lines and a half in length, and about as wide as the diameter of the pin, went through the hole at E, and passing parallel to the plane of the board, projected the image of the sun and the shadow of the pin at A. In these circumstances he observed,

1. That quite round the concave surface of this hoop, there were a multitude of coloured streaks; but that the space mAn , of about 18 degrees, the middle of which was occupied by the image of the sun, was covered with a faint light only.

2. The order of the colours in these streaks was generally such that the most refrangible rays were the nearest to the incident ray ECA; so that, beginning from the point A, the violet was the first and the red the last colour in each of the streaks. In some of

them, however, the colours were disposed in a contrary order.

3. The image of the sun, projected on each side of the point A, was divided by the shadow of the pin, which was bordered by two luminous streaks.

4. The coloured streaks were narrower in some parts of the hoop than others, and generally decreased in breadth in receding from the point A.

5. Among these coloured streaks, there were sometimes others which were white, a line or a line and an half in breadth, which were always bordered on both sides by a streak of orange colour, at least when the light of the sun was intense, and the chamber sufficiently dark.

From this experiment he thought it was evident, that the rays which passed beyond the pin were not the only ones that were decomposed, for that those which were reflected back from the pin were decomposed also; from which he concluded, that they must have undergone some refraction. He also thought that those which went beyond the pin suffered a reflection, so that they were all affected in a similar manner.

In order to account for these facts, our author describes the progress of a ray of light through an uniform atmosphere, which he supposes to surround the pin; and shows, that the differently refrangible rays will be separated at their emergence from it: but he refers to some experiments and observations in a future memoir, to demonstrate that all the coloured streaks are produced by rays that are both reflected and refracted.

To give some idea of his hypothesis, he shows that the ray ab , fig. 10. after being refracted at b , reflected at r and u , and again refracted at s and t , will be divided into its proper colours; the least refrangible or the red rays issuing at x , and the most refrangible or violet at y ; which agrees with his observations. Those streaks in which the colours appear in a contrary order he thinks are to be ascribed to inequalities in the surface of the pin. This might easily have been ascertained by turning the pin round; in which case these differently-coloured streaks would have changed their places.

If any person should choose to repeat these experiments, he observes that it requires that the sky be very clear and free from vapours, in order to exhibit the colours with the greatest distinctness; since even the vapours that are imperceptible will diminish the lustre of the colours on every part of the hoop, and even efface some of them, especially those which are on that part in which the beam of light enters, as at E, fig. 9. where the colours are always fainter than in any other place, and indeed can never be distinguished except when the hole E is confined by black substances, so as to intercept a part of the light that might reach the pin; and unless also those rays which go beyond the pin to form the image of the sun at A be stopped, so that no rays are visible except those that are reflected towards the hole, and which make the faint streaks.

The coloured streaks that are next the shadow of the pin, he shows, are formed by those rays which, entering the atmosphere, do not fall upon the pin; and, without any reflection, are only refracted at their entering

61 Account of Du Tour's hypothesis.

flection, refraction, and inflection, are probably brought about by the same forces.

We would extend this observation to all attempts of philosophers to explain the phenomena of nature by the *immediate* action of invisible fluids, magnetical, electrical, nervous, æthers, &c. and we would add, that all of them are equally illogical. They are all attempts to explain changes of motion by impulse; and proceed on the previous supposition, that the changes of motion by impulse are perfectly understood; a supposition quite gratuitous, nay false. We may challenge any philosopher to demonstrate, from unexceptionable principles, and by just argument, what will be the effect of one particle of matter in motion meeting with another particle at rest, these two particles constituting the whole of the universe. The question is to this day undecided.

But this is not all—changes of motion by impulse are very familiar, and the general laws are pretty well known; so that when it can be shown that impulse really operates in a phenomenon, we are satisfied with the explanation. When we see a glass ball hanging as a pendulum put in motion by the stroke of another equal ball similarly suspended, we think its motion is sufficiently explained by the common laws of collision. But this is a very incomplete view of the matter. It remains to be proved, that the motion was really produced by impulse, that is, by the one ball's coming into contact with the other; and we shall find that *real* impulse is far from being so familiar as we imagine.

When one object-glass of a very long telescope lies upon another, nothing is observed at the place of contact of the two spherical glasses, unless the weight of the upper one be considerable; in which case a greasy-like spot is observed. If now the upper glass be pressed on the other, the spot will increase in diameter, and have a coloured margin. By gradually increasing the pressure, the breadth of the coloured spot will increase, and it will be found to consist of concentric arches of different colours, increasing in number and breadth by an increase of pressure. When this is sufficiently great, a black or unreflecting spot appears in the middle, sharply defined, with a silvery margin, and increasing in breadth with the pressure. No additional pressure makes any change excepting in the diameters of the coloured rings. When the pressure is gradually diminished, the rings contract, the black spot vanishes, and all the colours vanish in the contrary order to that of their first appearance. When the pressure is measured which is necessary for producing the black spot, it is found considerably to exceed 800 pounds for every square inch of the black spot.

64
800 pounds weight on every square inch necessary to bring two bodies into apparent contact.

It is incontestably proved, that the coloured rings are produced by the reflection of light in those parts where the glasses are at certain small distances from each other, inseparable by means of the diameters of the coloured rings and the diameter of the spheres, of which the adjoining surfaces of the glasses are portions; and the want of reflection in the middle seems to indicate the want of this necessary distance, and that the two glasses are there in contact, making but one, their surfaces being flattened by compression. The glasses seem to be kept asunder by mutual forces, which are overcome by external pressure, and which again separate them when the pressure is removed.

When therefore the glass ball mentioned above puts the other in motion by striking it, we are intitled to say, that unless the pressure during the stroke has been equal to 800 pounds for every square inch of contact, the motion has been produced without contact or real impulse, by the action of repulsive forces exerted between the balls, in the same manner as would happen between two magnets floating on cork with their north poles fronting each other; in which case (if the motion has been sufficiently slow) the striking magnet will be brought to rest, and the other move off, with its original velocity, in the same manner as happens to the glass balls. Many such communications of motion happen, where we cannot say that the impulsive pressure is greater than that now mentioned; and in such cases we are well intitled to say, that the motion has been produced without real impulse, by repulsive forces acting at a distance. This evidently diminishes to a great degree the familiarity of the fact of impulse.

But we conclude too hastily, from the phenomena of the object glasses, that a pressure exceeding 800 pounds on the square inch will produce contact.

Blow a soap bubble, and let it fall on a piece of cloth, and cover it with a glass bell: after some time you will observe rings of colours on its upper part, which will increase in number and breadth, and be in every respect similar to those between the object-glasses. These arise from the gradual shining of the upper part of the soap bubble; a certain thickness of this, as well as of the interval between the glasses, invariably reflecting a certain colour. At last a black spot appears a-top, which is sharply defined, and increases in diameter. Soon after this the bubble bursts. Thus then there is a certain thickness necessary for enabling the plate of soap suds to reflect light so as to be very sensible. Analogy obliges us to extend this to the object-glasses, and to say, not that the glasses touch each other through the extent of the black spot, but that their distance is there too small for the sensible reflection of light; and it remains undecided whether any pressure, however great, can annihilate all distance between them. So far, therefore, from impulse being a familiar fact, and its supposed laws being proper and logical principles of reasoning and explanation, it appears extremely doubtful whether the fact has ever been observed; and it must therefore be against the rules of logic to adduce the laws of impulse for the explanation of any abstruse phenomenon.

66
It is doubtful whether impulse has ever been observed.

Æther and other fluid atmospheres have often been resorted to by philosophers puzzled for an explanation; and all this trouble has been taken to avoid the supposed difficulty of bodies acting at a distance. We now see that this is only putting the difficulty a step farther off. We may here add, that in all these attempts the very thing is supposed which the philosophers wish to avoid. These æthers have been fitted for their tasks by supposing them of variable densities. It is quite easy to show, that such a variation in density cannot be conceived without supposing the particles to act on particles not in contact with them, and to a distance as great as that to which the change of density extends. The very simplest form of an elastic fluid supposes this, either with respect to its own particles, or with respect to the particles of a still more subtle.

65
Motion produced without impulse.

66
It is doubtful whether impulse has ever been observed.

67
Supposed æthers furnish no account of the phenomena of inflection.

subtile fluid, from the interspersion of which it derives its elasticity. To get rid of one action at a distance, therefore, we introduce millions. Instead, therefore, of naturalists pluming themselves on such explanations, and having recourse, in all their difficulties, to the *æther* of Sir Isaac Newton, which they make a drudge, a *Mungo here, Mungo there, Mungo everywhere*; let us rather wonder how that great man, not more eminent for penetration and invention than for accuracy of conception and justness of reasoning, should so far forget himself, and deviate from that path of logical investigation in which he had most successfully advanced, and should, in his fabrication of *æther*, and application of it to explain the more abstruse phenomena of nature, at once transgress *all* the rules of philosophizing which he had prescribed to himself and others. Let this slip, this mark of frail mortality, put us on our guard, lest we also be seduced by the specious offers of explanation which are held out to us by means of invisible atmospheres of every kind.

68
Objects
sometimes
magnified
by the in-
flexion of
light.

M. Le Cat has well explained a phenomenon of vision depending upon the inflexion of light, which shows, that, in some cases objects appear magnified by this means. Looking at a distant steeple, when a wire, of a less diameter than the pupil of his eye, was held pretty near to it, and drawing it several times betwixt his eye and that object, he was surprised to find, that, every time the wire passed before his pupil, the steeple seemed to change its place, and some hills beyond the steeple seemed to have the same motion, just as if a lens had been drawn betwixt his eye and them.

Examining this appearance more attentively, he found that there was a position of the wire, but very difficult to keep, in which the steeple seemed not to have any motion, when the wire was passed before his eye; and in this case the steeple appeared less distinctly, and seemed to be magnified. These effects being similar to those of a lens, he attended to them more particularly; and placed his eye in such a manner with respect to the steeple, that the rays of light by which he saw it must come very close to the edge of a window, where he had placed himself to make his observations. Then passing the wire once more before his eye, he observed, that, when it was in the visual axis, the steeple appeared nearer to the window, on whichever side the wire was made to approach. He repeated this experiment, and constantly with the same result, the object being always magnified, and nearly doubled, by this means.

Plate
CCCLII.

This phenomenon is easily explained by fig. 14. in which B represents the eye, A the steeple, and C the diameter of the wire. The black lines express the cone of light by which the natural image of the steeple A is formed, and which is much narrower than the diameter of the wire C; but the dotted lines include not only that cone of light, stopped and turned out of its course by the wire, but also more distant rays inflected by the wire, and thereby thrown more converging into the pupil; just as would have been the effect of the interposition of a lens between the eye and the object. The result of this experiment was the same, whatever substances he made use of in the place of the wire, provided they were of the same diameter.

N^o 247.

§ 5. Discoveries concerning Vision.

MAUROLYCUS was the first who showed the true theory of vision, by demonstrating that the crystalline humour of the eye is a lens which collects the light issuing from external objects, and throws them upon the retina, where is the focus of each pencil. He did not however find out, that, by means of this refraction of the rays, an image of every visible object was formed upon the retina, though this seems hardly to have been a step beyond the discovery he had already made. Montucla indeed conjectures, that he was prevented from mentioning this part of the discovery by the difficulty of accounting for the upright appearance of objects, as the image on the retina is always inverted. This discovery was made by Kepler; but he, too, was much diffculted with the inverted position of the image. The rectification of these images, he says, is the business of the mind; which, when it perceives an impression on the lower part of the retina, considers it as made by rays proceeding from the higher parts of objects; tracing the rays back to the pupil, where they cross one another. But this hypothesis can scarcely be deemed satisfactory.—Kepler did not pretend to account for the manner in which the mind perceives the images upon the retina, and very much blames Vitellio for attempting prematurely to determine a question of this nature, and which indeed, he says, does not belong to optics. He accounts, however, though not in a satisfactory manner, for the power we have of seeing distinctly at different distances.

The discovery concerning vision was completed by Scheiner. For, in cutting away the coats of the back part of the eyes of sheep and oxen, and presenting several objects before them, within the usual distance of vision, he saw their images distinctly and beautifully painted upon the retina. He did the same thing with the human eye, and exhibited this curious experiment at Rome in 1625. He takes particular notice of the resemblance between the eye and the camera obscura, and explains a variety of methods to make the images of objects erect. As to the images of objects being inverted in the eye, he acquiesces in the reason given for it by Kepler. He knew that the pupil of the eye is enlarged in order to view remote objects, and that it is contracted while we are viewing those that are near; and this he proved by experiment, and illustrated by figures.

Scheiner also took a good deal of pains to ascertain the density and refractive power of all the humours of the eye, by comparing their magnifying power with that of water or glass in the same form and circumstances. The result of his inquiries was, that the aqueous humour doth not differ much from water in this respect, nor the crystalline from glass; and that the vitreous humour is a medium between both. He also very accurately and minutely traces the progress of the rays of light through all the humours of the eye; and after discussing every possible hypothesis concerning the proper seat of vision, he demonstrates that it is in the retina, and shows that this was the opinion of Alhazen, Vitellio, Kepler, and all the most eminent philosophers. He produces many reasons of his own for this hypothesis; answers a great number of objections

69
Discoveries
of Mauro-
lycus, Kep-
ler, &c.
concerning
vision.

70
Discoveries
of Scheiner.

OPTICS.
Fig. 1.

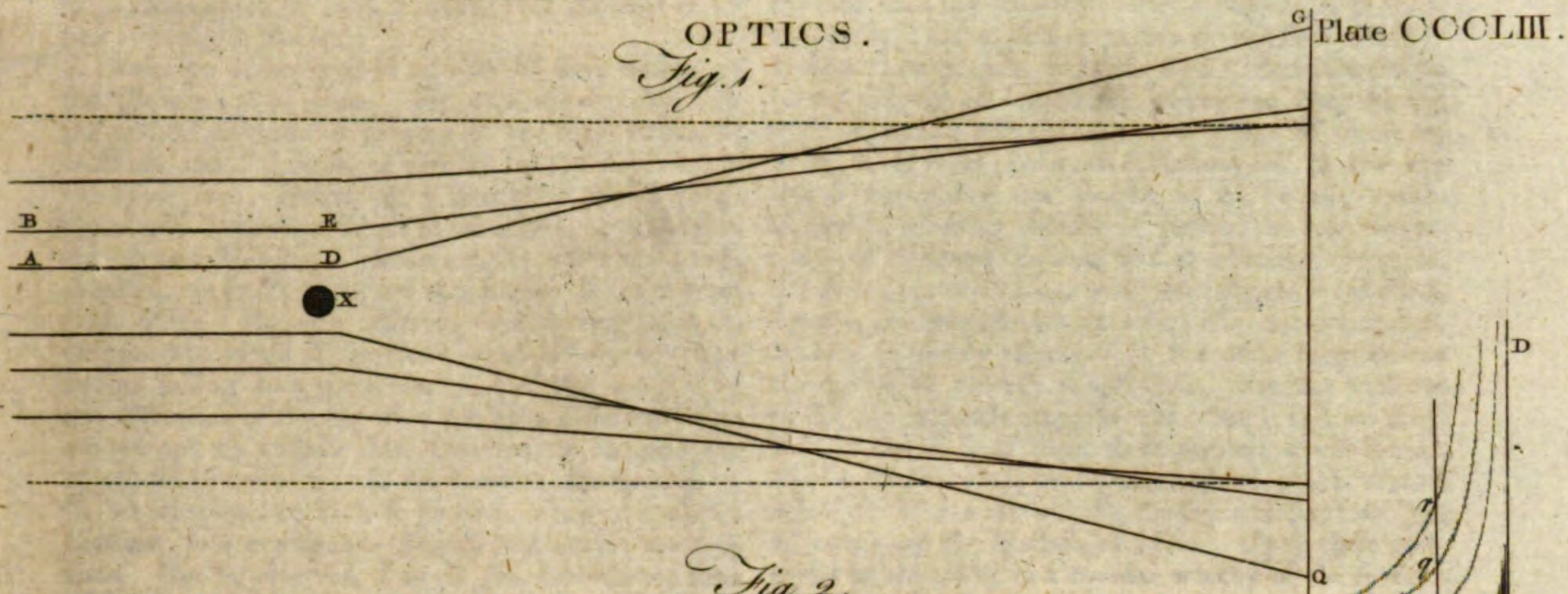


Fig. 2.

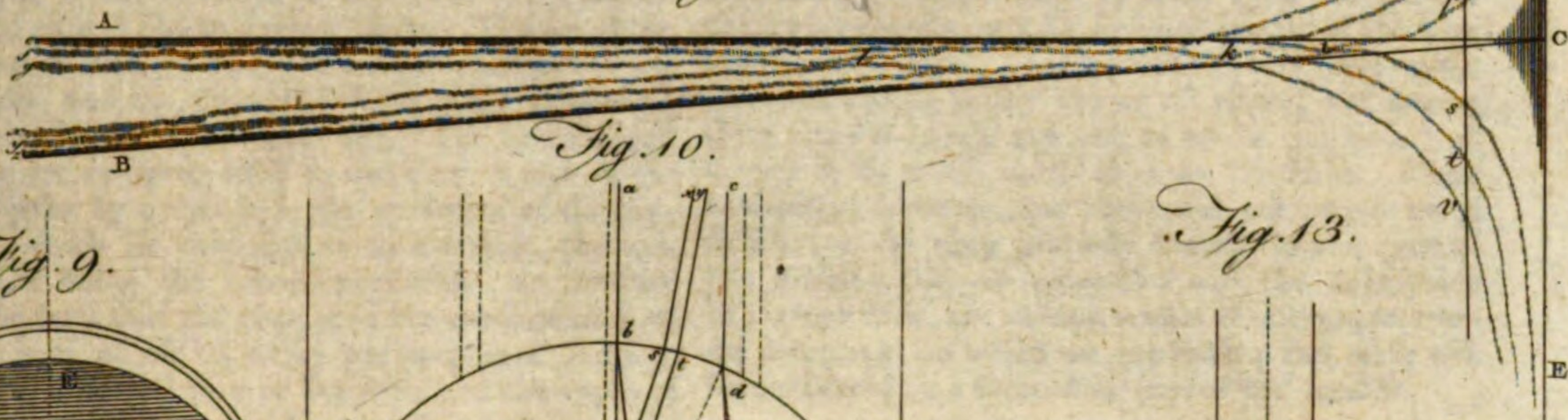


Fig. 10.

Fig. 9.

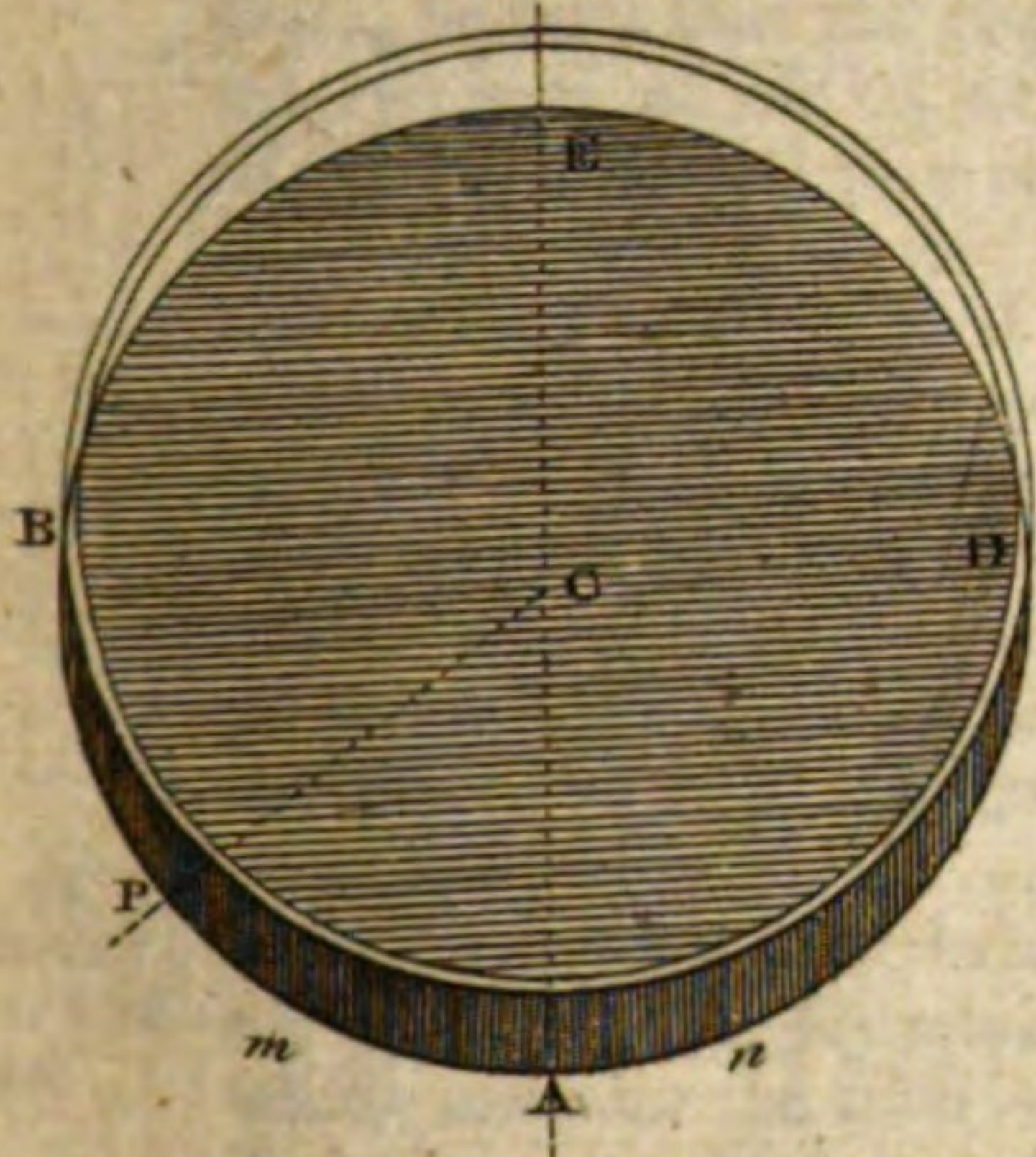


Fig. 13.

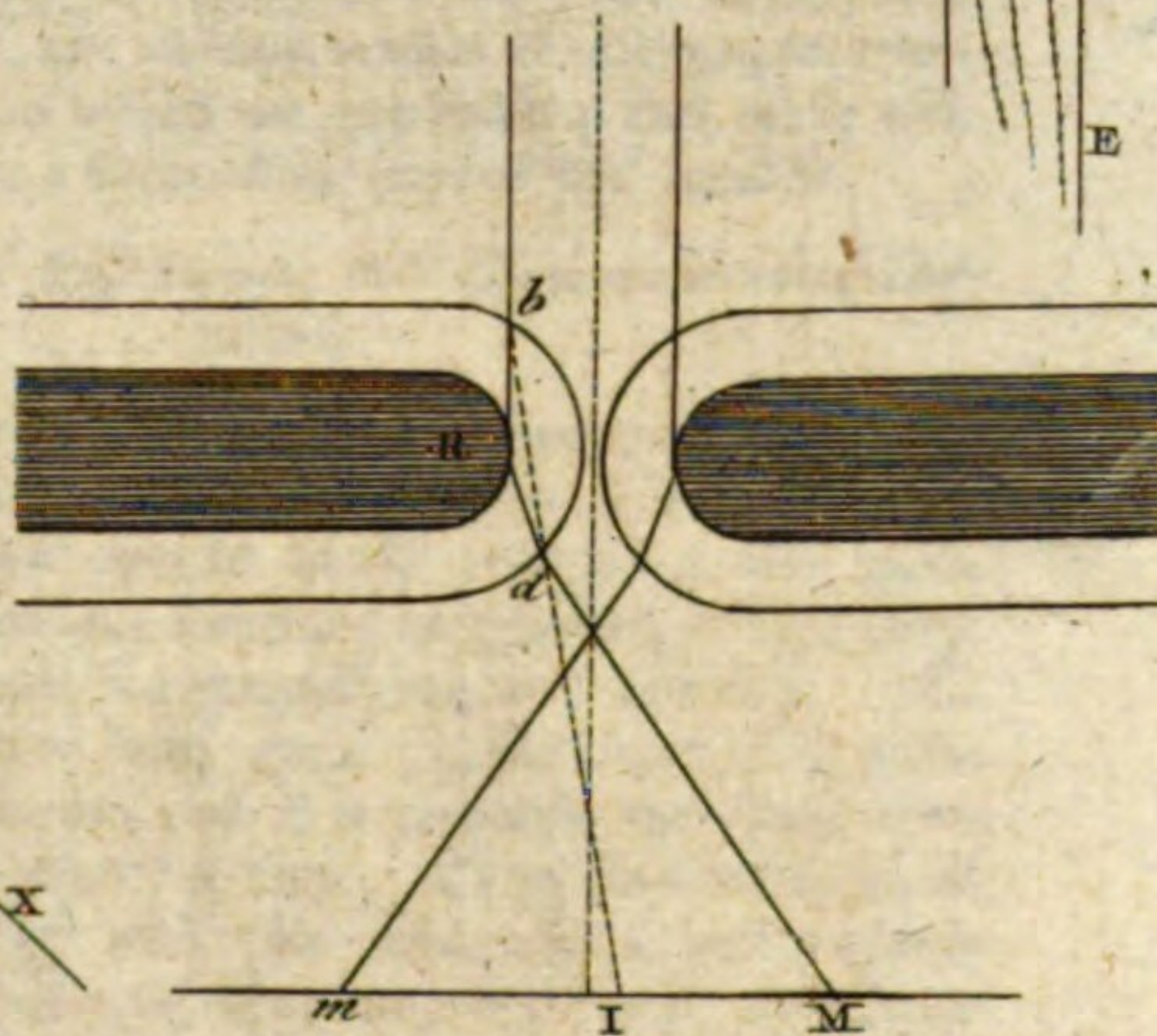


Fig. 12.

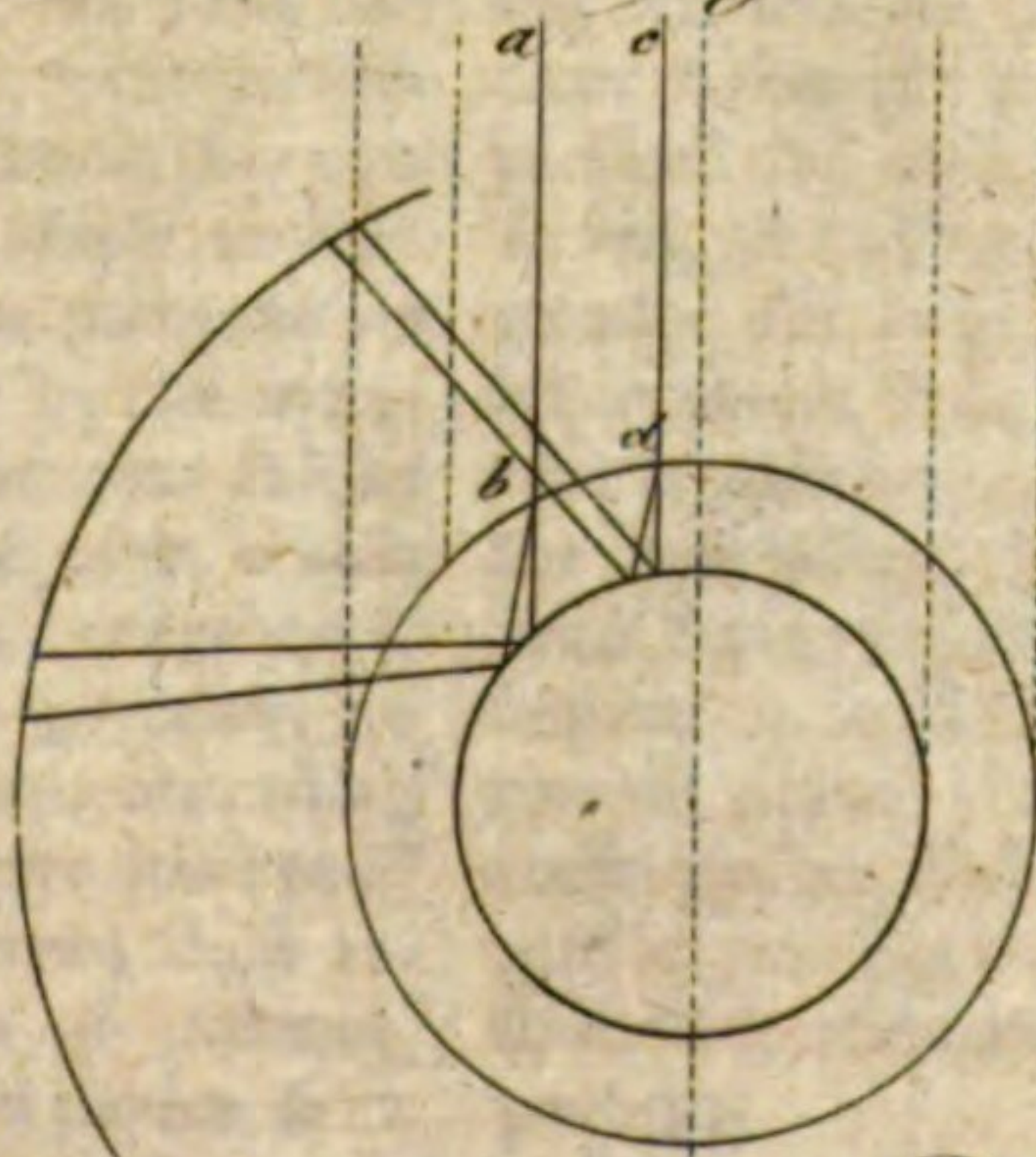


Fig. 11.

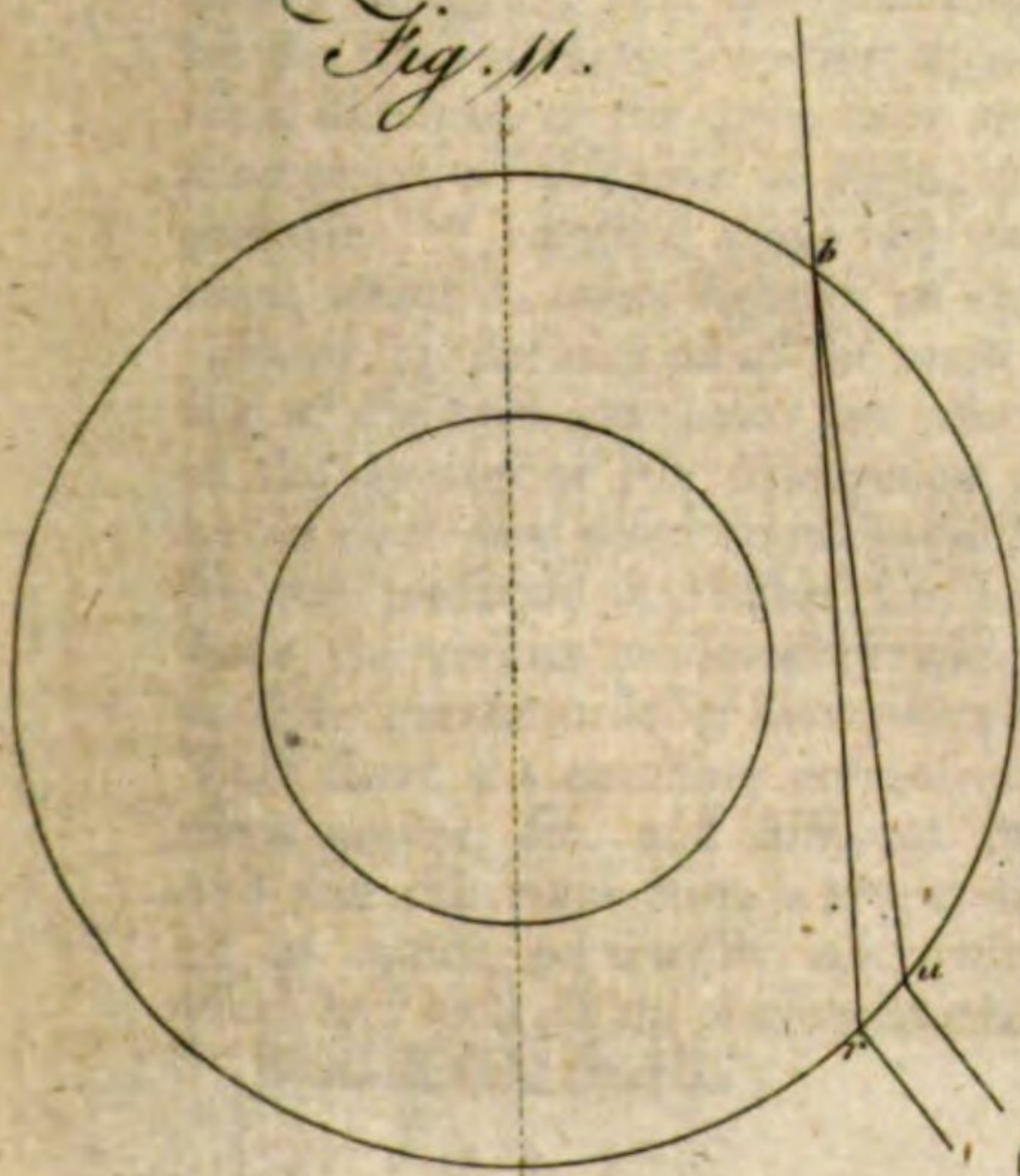


Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.



Fig. 7.



Fig. 8.

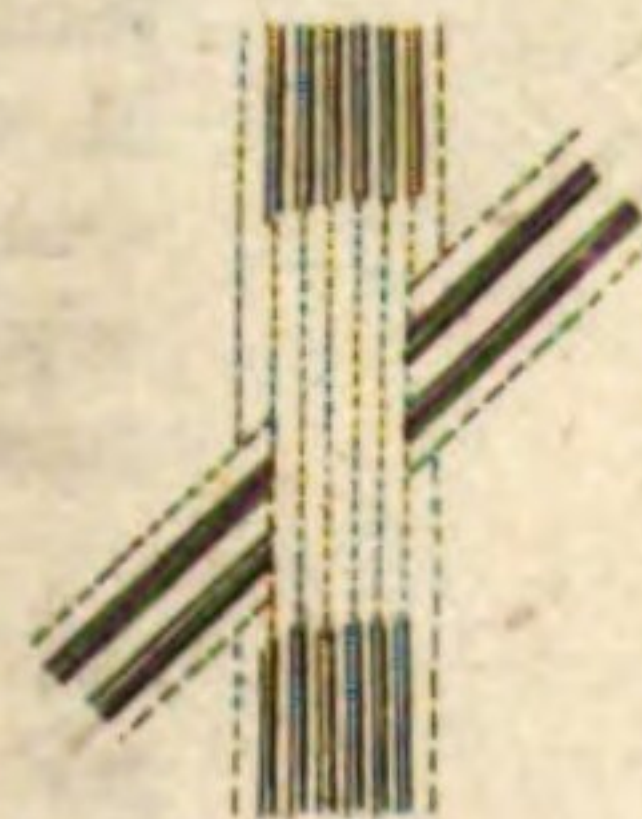


Fig. 14.



objections to it; and, by a variety of arguments, refutes the opinion of former times, that the seat of vision is in the crystalline.

71
Discoveries
of Des-
cartes.

Descartes makes a good number of observations on the phenomena of vision. He explains satisfactorily the natural methods of judging of the magnitudes, situations, and distances, of objects by the direction of the optic axes; comparing it to a blind man's judging of the size and distance of an object, by feeling at it with two sticks of a known length, when the hands in which he holds them are at a known distance from each other. He also observes, that having been accustomed to judge of the situation of objects by their images falling on a particular part of the eye; if by any distortion of the eye they fall on a different place, we are apt to mistake their situation, or imagine one object to be two; as, till we become accustomed to it, we imagine one stick to be two, when it is placed between two contiguous fingers laid across one another. But he observes, that all the methods we have of judging of the distances of objects are very uncertain, and extend but to narrow limits. The direction of the optic axes, he says, will not serve us beyond 15 or 20 feet, and the change of form of the crystalline not more than three or four feet. For he imagined that the eye conforms itself to the view of near or distant objects by a change in the curvature of the crystalline, which he supposed to be a muscle, the tendons of it being the processus ciliares. In another place, he says, that the change in the conformation of the eye is of no use to us for the purpose of judging of distances beyond four or five feet, and the angle of the optic axes not more than 100 or 200 feet: for this reason, he says, that the sun and moon are conceived to be much more nearly of the same size than they are in reality. White and luminous objects, he says, appear larger than others, and also the parts contiguous to those on which the rays actually impinge; and for the same reason, if the objects be small, and placed at a great distance, they will always appear round, the figure of the angles disappearing.

72
Berkeley's
theory of
vision.

The celebrated Berkeley bishop of Cloyne published, in 1709, *An Essay towards a New Theory of Vision*, which contains the solution of many difficulties. He does not admit that it is by means of those lines and angles, which are extremely useful in explaining the theory of optics, that different distances are judged of by the sense of sight; neither does he think that the mere direction of the optic axes, or the greater or less divergency of the rays of light, are sufficient for this purpose. "I appeal (says he) to any one's experience, whether, upon sight of an object, he compute its distance by the bigness of the angle made by the meeting of the two optic axes? or whether he ever thinks of the greater or less divergency of the rays which arrive from any point to his pupil? Nay, whether it be not perfectly impossible for him to perceive, by sense, the various angles wherewith the rays according to their greater or lesser divergency fell upon his eye?" That there is a necessary connection between these various angles, &c. and different degrees of distance, and that this connection is known to every person skilled in optics, he readily acknowledges; but "in vain (says he) shall all the mathematicians in the world tell

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me, that I perceive certain lines and angles, which introduce into my mind the various notions of distance, so long as I am myself conscious of no such thing." Distance, magnitude, and even figure, he maintains to be the objects of immediate perception only by the sense of touch; and that when we judge of them by sight, it is from different sensations felt in the eye which experience has taught us to be the consequence of viewing objects of greater or less magnitude, of different figures, and at different distances. These various sensations, with the respective distances, figures, and magnitudes by which they are occasioned, become so closely associated in the mind long before the period of distinct recollection, that the presence of the one instantly suggests the other; and we attribute to the sense of sight those notions which are acquired by the sense of touch, and of which certain visual sensations are merely the signs or symbols, just as words are the symbols of ideas. Upon these principles he accounts, in a manner worthy of the reader's attention, for single vision by both eyes, and for our perceiving objects erect by inverted images of them on the retina tunica. Subsequent writers have made great discoveries in the theory of vision; and among them there is hardly any one to whom this branch of science is so much indebted as to Dr Reid. Their reasonings, however, our limits will not permit us to detail, nor do they properly belong to this part of the article; they are connected with the description of the eye itself, the various modes of vision, and optical deceptions to which we are liable; and these will be considered in a succeeding part of this treatise.

§ 6. Of Optical Instruments, and Discoveries concerning them.

So little were the ancients acquainted with the science of Optics, that they seem to have had no instruments of the optical kind, excepting the glass globes and speculums formerly mentioned, which they used in some cases for magnifying and burning. Alhazen, as we have seen, gave the first hint of the invention of spectacles, and it is probable that they were found out soon after his time. From the writings of Alhazen, together with the observations and experiments of Roger Bacon, it is not improbable that some monks gradually hit upon the construction of spectacles; to which Bacon's lesser segment, notwithstanding his mistake concerning it, was a nearer approach than Alhazen's larger one. Whoever they were that pursued the discoveries of Bacon, they probably observed, that a very small convex glass, when held at a greater distance from the book, would magnify the letters more than when it was placed close to them, in which position only Bacon seems to have used it. In the next place, they might try whether two of these small segments of a sphere placed together, or a glass convex on both sides, would not magnify more than one of them. They would then find, that two of these glasses, one for each eye, would answer the purpose of reading better than one; and lastly, they might find, that different degrees of convexity suited different persons.

It is certain that spectacles were well known in the 13th century, and not long before. It is said that

L!

Alex.

Alexander Spina, a native of Pisa, who died in 1313, and who was very ingenious in executing whatever he saw or heard of as having been done by others, happened to see a pair of spectacles in the hands of a person who would not explain them to him; but that he succeeded in making a pair for himself, and immediately made the construction public, for the good of others. It is also inscribed on the tomb of Salvinus Armatus, a nobleman of Florence, who died 1317, that he was the inventor of spectacles.

74
Of concave
glasses.

The use of concave glasses, to help those persons who are short-sighted, was probably a discovery that followed not long after that of convex ones, for the relief of those whose sight is defective in the contrary extreme, though we find no trace of this improvement. Whoever made this discovery, it was probably the result of nothing more than a random experiment. Perhaps a person who was short-sighted, finding that convex glasses did him more harm than good, had the curiosity to make trial of a contrary curvature of the glass.

75
Descartes's
account of
the inven-
tion of tele-
scopes.

From this time, though both convex and concave lenses were sufficiently common, yet no attempt was made to form a telescope by a combination of them, till the end of the 16th century. Descartes considers James Metius, a person who was no mathematician, though his father and brother had applied to those sciences, as the first constructor of a telescope; and says, that as he was amusing himself with making mirrors and burning-glasses, he casually thought of looking through two of his lenses at a time; and that happening to take one that was convex and another that was concave, and happening also to hit upon a pretty good adjustment of them, he found, that, by looking through them, distant objects appeared very large and distinct. In fact, without knowing it, he had made a telescope.

76
Other ac-
counts.

Other persons say, that this great discovery was first made by John Lipperheim, a maker of spectacles at Middleburgh, or rather by his children; who, like Metius, were diverting themselves with looking thro' two glasses at a time, and placing them at different distances from one another. But Borellus, the author of a book intitled, *De vero telescopii inventore*, gives this honour to Zacharias Joannides, i. e. Jansen, another maker of spectacles at the same place, who made the first telescope in 1590; and it seems now to be the general opinion, that this account of Borellus is the most probable.

77
Borellus's
account
probably
the true
one.

Indeed, Borellus's account of the discovery of telescopes is so circumstantial, and so well authenticated, that it does not seem possible to call it in question. It is not true, he says, that this great discovery was made by a person who was no philosopher: for Zacharias Jansen was a diligent inquirer into nature; and being engaged in these pursuits, he was trying what uses could be made of lenses for those purposes, when he fortunately hit upon the construction.

This ingenious mechanic, or rather philosopher, had no sooner found the arrangement of glasses that produced the effect he desired, than he inclosed them in a tube, and ran with his instrument to prince Maurice; who, immediately conceiving that it might be of use to him in his wars, desired the author to keep it a secret. But this, though attempted for some time, was

found to be impossible; and several persons in that city immediately applied themselves to the making and selling of telescopes. One of the most distinguished of these was Hans Laprey, called *Lipperheim* by Sirturus. By him some person in Holland being very early supplied with a telescope, he passed with many for the inventor; but both Metius above-mentioned, and Cornelius Drebell of Almar, in Holland, applied to the inventor himself in 1620; as also did Galileo, and many others. The first telescope made by Jansen did not exceed 15 or 16 inches in length; but Sirturus, who says that he had seen it, and made use of it, thought it the best that he had ever examined.

78
The first
telescope
an exceed-
ingly good
one.

Jansen, having a philosophical turn, presently applied his instrument to such purposes as he had in view when he hit upon the construction. Directing it towards celestial objects, he distinctly viewed the spots on the surface of the moon; and discovered many new stars, particularly seven pretty considerable ones in the Great Bear. His son Joannes Zacharias, noted the lucid circle near the limb of the moon, from whence several bright rays seem to dart in different directions; and he says, that the full moon, viewed through this instrument, did not appear flat, but was evidently spherical, the middle part being prominent. Jupiter also, he says, appeared round, and rather spherical; and sometimes he perceived two, sometimes three, and at the most four small stars, a little above or below him; and, as far as he could observe, they performed revolutions round him; but this, he says, he leaves to the consideration of astronomers. This, it is probable, was the first observation of the satellites of Jupiter, though the person who made it was not aware of the importance of his discovery.

One Francis Fontana, an Italian, also claims the honour of invention; but as he did not pretend to have made it before the year 1608, and as it is well known that the instruments were made and sold in Holland some time before, his pretensions to a second discovery are not much regarded.

79
Honour of
the inven-
tion claim-
ed by Fontana.

There are some who say that Galileo was the inventor of telescopes; but he himself acknowledges, that he first heard of the instrument from a German; but he says, that being informed of nothing more than the effects of it, first by common report, and a few days after by a French nobleman, J. Badovere, at Paris, he himself discovered the construction, by considering the nature of refraction: and thus he had much more real merit than the inventor himself.

80
A telescope
made by
Galileo
without
seeing one.

The account of what Galileo actually did in this business is so circumstantially related by the author of his life, prefixed to the quarto edition of his works, printed at Venice in 1744, and it contains so many particulars, which cannot but be pleasing to every person who is interested in the history of telescopes, that we shall abridge a part of it, intermixing circumstances collected from other accounts.

About April or May, in 1609, it was reported at Venice, where Galileo (who was professor of mathematics in the university of Padua) then happened to be, that a Dutchman had presented to Count Maurice of Nassau, a certain optical instrument, by means of which, distant objects appeared as if they were near; but no farther account of the discovery had reached that

81
Account of
his disco-
veries.

that place, though this was near 20 years after the first discovery. Struck, however, with this account, Galileo instantly returned to Padua, considering what kind of an instrument this must be. The night following, the construction occurred to him; and the day after, putting the parts of the instrument together, as he had previously conceived of it, and notwithstanding the imperfection of the glasses that he could then procure, the effect answered his expectations, as he presently acquainted his friends at Venice, to which place he six days afterwards carried another and a better instrument that he had made, and where, from several eminences, he showed to some of the principal senators of that republic a variety of distant objects, to their very great astonishment. When he had made farther improvements in the instrument, he, with his usual generosity and frankness in communicating his discoveries, made a present of one of them to the Doge, Leonardo Donati, and at the same time to all the senate of Venice; giving along with the instrument a written paper, in which he explained the structure and wonderful uses that might be made of it both by land and at sea. In return for so noble an entertainment, the republic, on the 25th of August, in the same year, more than tripled his salary as professor.

Our philosopher, having amused himself for some time with the view of terrestrial objects, at length directed his tube towards the heavens; and, observing the moon, he found that the surface of it was diversified with hills and valleys, like the earth. He found that the *via lactea* and *nebulae* consisted of a collection of fixed stars, which, on account either of their vast distance, or extreme smallness, were invisible to the naked eye. He also discovered innumerable fixed stars dispersed over the face of the heavens, which had been unknown to all the ancients; and examining Jupiter, with a better instrument than any he had made before, he found that he was accompanied by four stars, which, in certain fixed periods, performed revolutions round him, and which, in honour of the house of Medici, he called *Medicean planets*.

This discovery he made in January 1610, new style; and continuing his observations the whole of February following, in the beginning of March next he published an account of all his discoveries, in his *Nuncius Sidereus*, printed at Venice, and dedicated to Cosmo great duke of Tuscany, who, by a letter which he wrote to him on the 10th of July 1610, invited him to quit Padua, and assigned him an ample stipend, as primate and extraordinary professor at Pisa, but without any obligation to read lectures, or to reside.

The extraordinary discoveries contained in the *Nuncius Sidereus*, which was immediately reprinted both in Germany and France, were the cause of much speculation and debate among the philosophers and astronomers of that time; many of whom could not be brought to give any credit to Galileo's account, while others endeavoured to decry his discoveries as being nothing more than fictions or illusions. Some could not be prevailed upon even to look through a telescope; so devoted were they to the system of Aristotle, and so averse to admit any other source of knowledge besides his writings. When it was found to be in vain

to oppose the evidence of sense, some did not scruple to assert that the invention was taken from Aristotle; and producing a passage from his writings, in which he attempts to give a reason why stars are seen in the day-time from the bottom of a deep well, said, that the well corresponded to the tube of the telescope, and that the vapours which arose from it gave the hint of putting glasses into it; and lastly, that in both cases the sight is strengthened by the transmission of the rays through a thick and dark medium. Galileo himself tells this story with a great deal of humour; comparing such men to alchymists, who imagine that the art of making gold was known to the ancients, but lay concealed under the fables of the poets.

In the beginning of July of the same year, 1610, Galileo being still at Padua, and getting an imperfect view of Saturn's ring, imagined that that planet consisted of three parts; and therefore, in the account which he gave of this discovery to his friends, he calls it *planetam tergemina*.

Whilst he was still at Padua, which must have been either in the same month of July, or the beginning of August following, he observed some spots on the face of the sun: but, contrary to his usual custom, he did not choose, at that time, to publish his discovery; partly for fear of incurring more of the hatred of many obstinate peripatetics; and partly in order to make more exact observations on this remarkable phenomenon, and to form some conjecture concerning the probable cause of it. He therefore contented himself with communicating his observations to some of his friends at Padua and Venice, among whom we find the name of father Paul. This delay, however, was the cause of this discovery being contested with him by the famous Scheiner, who likewise made the same observation in Oct. 1611, and we suppose had anticipated Galileo in the publication of it.

About the end of August, Galileo left Padua and went to Florence; and in November following he was satisfied, that, from the September preceding, Venus had been continually increasing in bulk, and that she changed her phases like the moon. About the end of March 1611, Galileo went to Rome, where he gratified the cardinals, and all the principal nobility, with a view of the new wonders he had discovered in the heavens, and among others the solar spots.

From these discoveries Galileo obtained the name of *Lynceus*, after one of the Argonauts, who was famous in antiquity for the acuteness of his sight; and moreover, the marquis of Monticelli instituted an academy, with the title of *Dè Lincei*, and made him a member of it. Twenty-nine years Galileo enjoyed the use of his telescope, continually enriching astronomy with his observations: but by too close an application to that instrument, and the detriment he received from the nocturnal air, his eyes grew gradually weaker, till in 1639 he became totally blind; a calamity which, however, neither broke his spirits, nor interrupted the course of his studies.

The first telescope that Galileo constructed magnified only three times: but presently after, he made another which magnified 18 times; and afterwards, with great trouble and expence, he constructed one that magnified 33 times; and with this it was that he discovered the satellites of Jupiter and the spots of the sun.

84
The rationale of the instrument first discovered by Kepler.

Notwithstanding Galileo must be allowed to have considerable merit with respect to telescopes, it was neither that of the person who first hit upon the construction, nor that of him who thoroughly explained the *rationale* of the instrument. This important service to science was performed by John Kepler, whose name is famous on many accounts in the annals of philosophy, and especially by his discovery of the great law of motion respecting the heavenly bodies; which is, that the squares of their periodical times are as the cubes of their distances from the body about which they revolve; a proposition which, however, was not demonstrated before Sir Isaac Newton. Kepler was astronomer to several of the emperors of Germany; he was the associate of the celebrated astronomer Tycho Brahe, and the master of Descartes.

Kepler made several discoveries relating to the nature of vision; and not only explained the *rationale* of the telescope which he found in use, but also pointed out methods of constructing others of superior powers and more commodious application.

It was Kepler who first gave a clear explication of the effects of lenses, in making the rays of a pencil of light converge or diverge. He showed, that a plano-convex lens makes rays that were parallel to its axis, to meet at the distance of the diameter of the sphere of convexity; but that if both sides of the lens be equally convex, the rays will have their focus at the distance of the radius of the circle, corresponding to that degree of convexity. But he did not investigate any rule for the foci of lenses unequally convex. He only says, in general, that they will fall somewhere in the medium, between the foci belonging to the two different degrees of convexity. It is to Cavallieri that we owe this investigation. He laid down this rule: As the sum of both the diameters is to one of them, so is the other to the distance of the focus. All these rules concerning convex lenses are applicable to those that are concave; with this difference, that the focus is on the contrary side of the glass, as will be particularly shown in the second part of this treatise.

85
General reason of the effects of telescopes.

The principal effects of telescopes depend upon these plain maxims, *viz.* That objects appear larger in proportion to the angles which they subtend at the eye; and the effect is the same whether the pencils of rays, by which objects are visible to us, come directly from the objects themselves, or from any place nearer to the eye, where they may have been united so as to form an image of the object; because they issue again from those points where there is no real substance, in certain directions, in the same manner as they did from the corresponding points in the objects themselves.

In fact, therefore, all that is effected by a telescope is, first to make such an image of a distant object, by means of a lens or mirror; and then to give the eye some assistance for viewing that image as near as possible; so that the angle which it shall subtend at the eye, may be very large compared with the angle which the object itself would subtend in the same situation. This is done by means of an eye-glass, which so refracts the pencils of rays, as that they may afterwards be brought to their several foci by the natural humours of the eye. But if the eye was so formed as to be able to see the image with sufficient distinctness at the same distance without any eye-glass, it would appear to him

as much magnified as it does to another person who makes use of a glass for that purpose, though he would not in all cases have so large a field of view.

If, instead of an eye glass, an object, or the image of an object, be looked at through a small hole in a thin plate or piece of paper, held close to the eye, it may be viewed very near to the eye, and, at the same distance, the apparent magnitude of the object will be the same in both cases. For if the hole be so small as to admit but a single ray from every distinct point of the object, these rays will fall upon the retina in as many other distinct points, and make a distinct image. They are only pencils or cones of rays, which have a sensible base, as the breadth of the pupil, that are capable, by their spreading on the retina, of producing an indistinct image. As very few rays, however, can be admitted through a small hole, there will seldom be light sufficient to view any object to advantage in this manner.

If no image be actually formed by the foci of the pencils without the eye, yet if, by the help of any eye-glass, the pencils of rays shall enter the pupil, just as they would have done from any place without the eye, the visual angle will be the same as if an image had actually been formed in that place. Objects will not appear inverted through this telescope, because the pencils which form the images of them, only cross one another once, *viz.* at the object glass, as in natural vision they do in the pupil of the eye.

Such is the telescope that was first discovered and used by philosophers; and it is remarkable that it should be of a much more difficult construction than some other kinds that have been invented since. The great inconvenience attending it is, that the field of view is exceedingly small. For since the pencils of rays enter the eye very much diverging from one another, but few of them can be intercepted by the pupil, this inconvenience increases with the magnifying power of the telescope; so that philosophers at this day cannot help wondering, that it was possible, with such an instrument, for Galileo and others to have made the discoveries they did. It must have required incredible patience and address. No other telescope, however, than this, was so much as thought of for many years after the discovery. Descartes, who wrote 30 years after, mentions no others as actually constructed, though Kepler had suggested some.

It is to this great man that we are indebted for the construction of what we now call the *astronomical telescope*, being the best adapted for the purpose of viewing the heavenly bodies. The *rationale* of this instrument is explained, and the advantages of it are clearly pointed out, by this philosopher, in his *Catoptrics*; but, what is very surprising, he never actually reduced his excellent theory into practice. Montucla conjectures, that the reason why he did not make trial of his new construction was, his not being aware of the great increase of the field of view; so that being engaged in other pursuits, he might not think it of much consequence to take any pains about the construction of an instrument, which could do little more than answer the same purpose with those of which he was already possessed. He must also have foreseen, that the length of this telescope must have been greater in proportion to its magnifying power; so that it might appear to him to

86
Galilean telescope more difficult of construction than others.

87
Telescopes improved by Kepler.

88
His method
first put in
practice by
Scheiner.

be upon the whole not quite so good a construction as the former.

It was not long, however, before Kepler's new scheme of a telescope was executed; and the first person who actually made an instrument of this construction was Father Scheiner, who has given a description of it in his *Rosa Ursina*, published in 1630. If, says he, you insert two similar lenses (that is, both convex) in a tube, and place your eye at a convenient distance, you will see all terrestrial objects inverted, indeed, but magnified and very distinct, with a considerable extent of view. He afterwards subjoins an account of a telescope of a different construction, with two convex eye-glasses, which again reverses the images, and makes them appear in their natural position. This disposition of the lenses had also been pointed out by Kepler, but had not been reduced to practice by him, any more than the former. This construction, however, answered the end but very imperfectly; and Father Rheita presently after hit upon a better construction, using three eye-glasses instead of two. This got the name of the *terrestrial telescope*, being chiefly used for terrestrial objects.

The first and last of these constructions are those which are now in common use. The proportion in which the first telescope magnifies, is as the focal length of the object-glass to that of the eye-glass.—The only difference between the Galilean telescope and the other is, that the pencils by which the extremities of any object are seen in this case, enter the eye diverging; whereas, in the other, they enter it converging; but if the sphere of concavity in the eye-glass of the Galilean telescope be equal to the sphere of convexity in the eye-glass of another telescope, their magnifying power will be the same. The concave eye-glass, however, being placed between the object-glass and its focus, the Galilean telescope will be shorter than the other, by twice the focal length of the eye-glass. Consequently, if the length of the telescopes be the same, the Galilean will have the greater magnifying power.

89
Huygens
greatly im-
proves the
telescopes
of Scheiner
and Rheita.

The invention of the telescope and microscope having incited mathematicians to a more careful study of dioptrics, and this having soon become almost a perfect science, by means of the discovery of Snellius, many different constructions were offered to the public. Huygens was particularly eminent for his systematic knowledge of the subject, and is the author of the chief improvements which have been made on all the dioptrical instruments till the time of Mr Dollond's discovery. He was well acquainted with the theory of aberration arising from the spherical figure of the glasses, and has showed several ingenious methods of diminishing them by proper constructions of the eye-pieces. He first showed the advantages of two eye-glasses on the astronomical telescope and double microscope, and gave rules for this construction, which both enlarges the field and shortens the instrument. Mr Dollond adapted his construction to the terrestrial telescope of De Rheita; and his five eye-glasses are nothing but the Huygenian eye-piece doubled. This construction has been too hastily given up by the artists of the present day for another, also of Mr Dollond's, of four glasses.

Vision is more distinct in the Galilean telescope than

in the other, owing perhaps in part to there being no intermediate image between the eye and the object. Besides the eye-glass being very thin in the centre, the rays will be less liable to be distorted by irregularities in the substance of the glass. Whatever be the cause, we can sometimes see Jupiter's satellites very clearly in a Galilean telescope not more than twenty inches or two feet long; when one of four or five feet, of the common sort, will hardly make them visible.

The same Father Rheita, to whom we are indebted for the useful construction of a telescope for land-objects, invented a binocular telescope, which Father Cherubin, of Orleans, endeavoured to bring into use afterwards. It consists of two telescopes fastened together, and made to point to the same object. When this instrument is well fixed, the object appears larger, and nearer to the eye, when it is seen through both the telescopes, than through one of them only, though they have the very same magnifying power. But this is only an illusion, occasioned by the stronger impression that two equal images, equally illuminated, make upon the eye. This advantage, however, is counterbalanced by the inconvenience attending the use of it.

The first who distinguished themselves in grinding telescopic glasses were two Italians, Eustachio Divini at Rome, and Campani at Bologna, whose fame was much superior to that of Divini, or that of any other person of his time; though Divini himself pretended, that, in all the trials that were made with their glasses, his, of a great focal distance, performed better than those of Campani, and that his rival was not willing to try them fairly, viz. with equal eye-glasses. It is generally supposed, however, that Campani really excelled Divini, both in the goodness and the focal length of his object-glasses. It was with telescopes made by Campani that Cassini discovered the nearest satellites of Saturn. They were made by the express order of Louis XIV. and were of 86, 100, and 136 Parisian feet focal length.

Campani sold his lenses for a great price, and took every possible method to keep his art of making them a secret. His laboratory was inaccessible to all the world, till after his death; when it was purchased by Pope Benedict XIV. who made a present of it to the academy called the *Institute*, established in that city; and by the account which M. Fougereux has given of what he could discover from it, we learn, that (except a machine, which M. Campani constructed, to work the basons on which he ground his glasses) the goodness of his lenses depended upon the clearness of his glass, his Venetian tripoli, the paper with which he polished his glasses, and his great skill and address as a workman. It was also the general opinion at Bologna, that he owed a great part of his reputation to the secrecy and air of mystery which he affected; and that he made a great number of object-glasses which he rejected, showing only those that were very good. He made few lenses of a very great focal distance; and having the misfortune to break one of 141 feet in two pieces, he took incredible pains to join the two parts together, which he did at length effectually, so that it was used as if it had been entire; but it is not probable that he would have taken so much pains about it, if, as he pretended, he could very easily have made another as good.

Sir

90
Vision most
distinct in
the Galilean
telescopes.

91
Binocular
telescopes.

92
Telescopes
of Campani
and Divini.

Sir Paul Neille, Dr Hooke says, made telescopes of 36 feet, pretty good, and one of 50, but not of proportional goodness. Afterwards Mr Reive first, and then Mr Cox, who were the most celebrated in England as grinders of optic glasses, made some good ones of 50 and 60 feet focal distance, and Mr Cox made one of 100; but how good, Dr Hooke could not assert.

Borelli also, in France, made object-glasses of a great focal length, one of which he presented to the Royal Society; but we do not find any particular account of their goodness.

93
Extraordi-
nary object-
glass made
by Mr
Auzout.

With respect to the focal length of telescopes, these and all others were far exceeded by M. Auzout, who made one object-glass of 600 feet focus; but he was never able to manage it, so as to make any use of it. Hartsocker is even said to have made some of a still greater focal length; but this ingenious mechanic, finding it impossible to make use of object-glasses the focal distance of which was much less than this, when they were inclosed in a tube, contrived a method of using them without a tube, by fixing them at the top of a tree, a high wall, or the roof of a house.

94
Telescopes
used with-
out tubes.

Mr Huygens, who was also an excellent mechanic, made considerable improvements in the method of using an object-glass without a tube. He placed it at the top of a very long pole, having previously inclosed it in a short tube, which was made to turn in all directions, by means of a ball and socket. The axis of this tube he could command with a fine silken string, so as to bring it into a line with the axis of another short tube, which he held in his hand, and which contained the eye-glass. In this method he could make use of object-glasses of the greatest magnifying power, at whatever altitude his object was, and even in the zenith, provided his pole was as long as his telescope; and, to adapt it to the view of objects of different altitudes, he had a contrivance, by which he could raise or depress a stage that supported his object-glass at pleasure.

M. De la Hire made some improvement in this method of managing the object-glass, fixing it in the centre of a board, and not in a tube; but as it is not probable that this method will ever be made use of, since the discovery of both reflecting and achromatic telescopes, which are now brought to great perfection, and have even micrometers adapted to them, we shall not describe this apparatus minutely; but shall only give a drawing of M. Huygens's pole, which, with a very short explanation, will be sufficient for the purpose. In fig. 1. *a* represents a pulley, by the help of which a stage *c, d, e, f*, (that supports the object-glass *k*, and the apparatus belonging to it), may be raised higher or lower at pleasure, the whole being counterpoised by the weight *b*, fastened to a string *g*. *n*, is a weight, by means of which the centre of gravity of the apparatus belonging to the object-glass is kept in the ball and socket, so that it may be easily managed by the string *l*, and its axis brought into a line with the eye-glass at *o*. When it was very dark, M. Huy-

Plate
CCCLIV.

gens was obliged to make his object-glass visible by a lantern *y*, so constructed as to throw the rays of light in a parallel direction up to it.

The recollection of the incredible pains which philosophers of the last age took in making observations, and the great expences they were obliged to be at for that purpose, should make us sensible of the obligations we are under to such men as Gregory, Newton, and Dollond, who have enabled us to get clearer and more satisfactory views of the remote parts of our system, with much less labour and expence; and should likewise make us more diligent and solicitous to derive all the advantages we possibly can from such capital improvements.

The reason why it is necessary to make the common dioptric telescopes so very long, is, that the length of them must be increased in no less a proportion than the duplicate of the increase of their magnifying power; so that, in order to magnify twice as much as before, with the same light and distinctness, the telescope must be lengthened four times; and to magnify thrice as much, nine times; and so on.

95
Why diop-
tric tele-
scopes must
be made so
long.

Before we mention the reflecting telescope, it must be observed, that M. Auzout, in a paper delivered to the Royal Society, observed, that the apertures which the object-glasses of refracting telescopes can bear with distinctness, are in about a sub-duplicate proportion to their lengths; and upon this supposition he drew up a table of the apertures proper for object-glasses of a great variety of focal lengths, from 4 inches to 400 feet. Upon this occasion, however, Dr Hooke observed, that the same glass will bear a greater or less aperture, according to the less or greater light of the object. If, for instance, he was viewing the sun, or Venus, or any of the fixed stars, he used smaller apertures: but if he wanted to view the moon by daylight; or Saturn, Jupiter, or Mars, by night, he used a larger aperture.

96
Of the a-
pertures of
refracting
telescopes.

But the merit of all these improvements was in a manner cancelled by the discovery of the much more commodious reflecting telescope. For a refracting telescope, even of 1000 feet focus, supposing it possible to be made use of, could not be made to magnify with distinctness more than 1000 times; whereas a reflecting telescope, not exceeding 9 or 10 feet, will magnify 1200 times.

"It must be acknowledged (says Dr Smith in his *Complete System of Optics*), that Mr James Gregory of Aberdeen was the first inventor of the reflecting telescope; but his construction is quite different from Sir Isaac Newton's, and not nearly so advantageous."

97
History of
the reflect-
ing tele-
scope.

But, according to Dr Pringle, Merfennus was the man who entertained the first thought of a reflector. A telescope with specula he certainly proposed to the celebrated Descartes many years before Gregory's invention, though indeed in a manner so very unsatisfactory, that Descartes, who had given particular attention to the improvement of the telescope, was so far from approving the proposal, that he endeavoured to convince Merfennus of its fallacy (B). Dr Smith,

it

(B) *Lettres de Descartes*, tom. ii. printed at Paris in 1657, lett. 29. and 32. See this point discussed by two learned and candid authors, M. le Roy in the *Encyclopédie*, under the article *Telescope*, and M. Montecula in *Hist. des Mathem.* tom. ii. p. 644.

it appears, had never perused the two letters of Descartes to Mersennus which briefly touch on that subject.

Again, as to his assertion, that Gregory's construction was not nearly so advantageous as Newton's, it may be accounted for from his having set it down early in the composition of his work, and forgetting to qualify it afterwards, when, before the publication, he had received pretty sure information to the contrary. Or perhaps he was influenced by the example of Dr Bradley, who had been a most successful observer, and yet had always preferred the Newtonian telescope to the other. But we must certainly adjudge the superiority to the latter, as that is now, and has been for several years past, the only instrument of the kind in request.

Gregory, a young man of an uncommon genius, was led to the invention, in seeking to correct two imperfections of the common telescope: the first was its too great length, which made it less manageable; the second, the incorrectness of the image. Mathematicians had demonstrated, that a pencil of rays could not be collected in a single point by a spherical lens; and also, that the image transmitted by such a lens would be in some degree incurvated. These inconveniences he believed would be obviated by substituting for the object-glass a metallic speculum, of a parabolic figure, to receive the image, and to reflect it towards a small speculum of the same metal: this again was to return the image to an eye-glass placed behind the great speculum, which for that purpose was to be perforated in its centre. This construction he published in 1663, in his *Optica Promota*. But as Gregory, by his own account, was endowed with no mechanical dexterity, nor could find any workman capable of realizing his invention, after some fruitless attempts in that way he was obliged to give up the pursuit: and probably, had not some new discoveries been made in light and colours, a refracting telescope would never more have been thought of, considering the difficulty of the execution, and the small advantages that could accrue from it, deducible from the principles of optics that were then known.

But Newton, whose genius for experimental knowledge was equal to that for geometry, happily interposed, and saved this noble invention from well-nigh perishing in its infant state. He likewise at an early period of life had applied himself to the improvement of the telescope; but imagining that Gregory's specula were neither very necessary, nor likely to be executed, he began with prosecuting the views of Descartes, who aimed at making a more perfect image of an object, by grinding lenses, not to the figure of a sphere, but to that of one of the conic sections. Now, whilst he was thus employed, three years after Gregory's publication, he happened to take to the examination of the colours formed by a prism, and having by the means of that simple instrument discovered the different refrangibility of the rays of light, he then perceived that the errors of telescopes, arising from that cause alone, were some hundred times greater than such as were occasioned by the spherical figure of lenses. This circumstance forced, as it were, Newton to fall into Gregory's track, and to turn his thoughts to reflectors. "The different refrangibility of the

rays of light (says he, in a letter to Mr Oldenburg, secretary to the Royal Society, dated in Feb. 1672) made me take reflections into consideration; and finding them regular, so that the angle of reflection of all sorts of rays was equal to the angle of incidence, I understood that by their mediation optic instruments might be brought to any degree of perfection imaginable, providing a reflecting substance could be found which would polish as finely as glass, and reflect as much light as glass transmits, and the art of communicating to it a parabolic figure be also obtained. Amidst these thoughts I was forced from Cambridge by the intervening plague, and it was more than two years before I proceeded further."

It appears, then, that if Newton was not the first inventor of the reflecting telescope, he was the main and effectual inventor. By the force of his admirable genius, he fell upon this new property of light; and thereby found, that all lenses, of whatever figure, would be affected more or less with such prismatic aberrations of the rays as would be an insuperable obstacle to the perfection of a dioptric telescope.

It was towards the end of 1668, or in the beginning of the following year, when Newton, being thus obliged to have recourse to reflectors, and not relying on any artificer for making his specula, set about the work himself, and early in the year 1672 completed two small reflecting telescopes. In these he ground the great speculum into a spherical concave; not but that he approved of the parabolic form proposed by Gregory, though he found himself unable to accomplish it. In the letter that accompanied one of these instruments which he presented to the Society, he writes, "that though he then despaired of performing that work (to wit, the parabolic figure of the great speculum) by geometrical rules, yet he doubted not but that the thing might in some measure be accomplished by mechanical devices."

Not less did the difficulty appear to find a metallic substance that would be of a proper hardness, have the fewest pores, and receive the smoothest polish: a difficulty in truth which he deemed almost unsurmountable, when he considered, that every irregularity in a reflecting surface would make the rays of light stray five or six times more out of their due course, than the like irregularities in a refracting one. In another letter, written soon after, he tells the secretary, "that he was very sensible that metal reflects less light than glass transmits; but as he had found some metallic substances to be more strongly reflective than others, to polish better, and to be freer from tarnishing than others, so he hoped that there might in time be found out some substances much freer from these inconveniences than any yet known." Newton therefore laboured till he found a composition that answered in some degree, and left it to those who should come after him to find a better, and presented a reflecting telescope to the Royal Society; from whom he received such thanks as were due to so curious and valuable a present. And Huygens, one of the greatest geniuses of the age, and himself a distinguished improver of the refractor, no sooner was informed by Mr Oldenburg of the discovery, than he wrote in answer, "that it was an admirable telescope; and that Mr Newton had well considered the advantage which a concave:

concave Speculum had above convex glasses in collecting the parallel rays, which according to his own calculation was very great: Hence that Mr Newton could give a far greater aperture to that Speculum than to an object-glass of the same distance of focus, and consequently much more magnify in his way than by an ordinary telescope: Besides, that by the reflector he avoided an inconvenience inseparable from object-glasses, which was the obliquity of both their surfaces, which vitiated the refraction of the rays that pass towards the sides of the glass, and did more hurt than men were aware of: Again, that by the mere reflection of the metalline Speculum there were not so many rays lost as in glasses, which reflected a considerable quantity by each of their surfaces, and besides intercepted many of them by the obscurity of their matter: That the main business would be, to find a matter for this Speculum that would bear as good and even a polish as glass. Lastly, he believed that Mr Newton had not been without considering the advantage which a parabolic Speculum would have over a spherical one in this construction; but had despaired, as he himself had done, of working other surfaces than spherical ones with due exactness." Huygens was not satisfied with thus expressing to the society his high approbation of the late invention; but drew up a favourable account of the new telescope, which he caused to be published in the *Journal des Sçavans* for the year 1672, and by that channel it was soon known over Europe.

But how excellent soever the contrivance was; how well soever supported and announced to the public; yet whether it was that the artists were deterred by the difficulty and labour of the work, or that the discoveries even of a Newton were not to be exempted from the general fatality attending great and useful inventions, *the making a slow and vexatious progress to the authors*; the fact is, that, excepting an unsuccessful attempt which the society made, by employing an artificer to imitate the Newtonian construction, but upon a larger scale, and a disguised Gregorian telescope, set up by Cassgrain abroad as a rival to Newton's, and that in theory only (for it never was put in execution by the author), no reflector was heard of for nearly half a century after. But when that period was elapsed, a reflecting telescope was at last produced to the world of the Newtonian construction by Dr Hadley, which the author had the satisfaction to find executed in such a manner as left no room to fear that the invention would any longer continue in obscurity.

This memorable event was owing to the genius, dexterity, and application, of Mr Hadley the inventor of the reflecting quadrant, another most valuable instrument. The two telescopes which Newton had made were but six inches long, were held in the hand for viewing objects, and in power were compared to a six-foot refractor; whereas Hadley's was above five feet long, was provided with a well-contrived apparatus for managing it, and equalled in performance the famous aerial telescope of Huygens of 123 feet in length. Excepting as to the manner of making the specula, we have, in the transactions of 1723, a complete description, with a figure, of this telescope, together with that of the machine for mo-

N^o 247.

ving it; but, by a strange omission, Newton's name is not once mentioned in that paper, so that any person not acquainted with the history of the invention, and reading that account only, might be apt to conclude that Hadley had been the sole contriver of it.

The same celebrated artist, after finishing two telescopes of the Newtonian construction, accomplished a third in the Gregorian way; but, it would seem, less successfully, by Dr Smith's declaring so strongly in favour of the other. Mr Hadley spared no pains to instruct Mr Molyneux and the reverend Dr Bradley; and when those gentlemen had made a sufficient proficiency in the art, being desirous that these telescopes should become more public, they liberally communicated to some of the principal instrument-makers of London the knowledge they had acquired from him. Now such scholars, as it is easy to imagine, soon advanced beyond their masters, and completed reflectors by other and better methods than what had been taught them.

Certain it is, at least, that Mr James Short, as early as the year 1734, had signalised himself at Edinburgh by his work of this kind. Mr Maclaurin wrote that year to Dr Jurin, "that Mr Short, who had begun with making glass specula, was then applying himself to improve the metallic; and that, by taking care of the figure, he was enabled to give them larger apertures than others had done; and that upon the whole they surpassed in perfection all that he had seen of other workmen." He added, "that Mr Short's telescopes were all of the Gregorian construction; and that he had much improved that excellent invention." This character of excellence Mr Short maintained to the last; and with the more facility, as he had been well grounded both in the geometrical and philosophical principles of optics, and upon the whole was a most intelligent person in whatever related to his profession. It was supposed he had fallen upon a method of giving the parabolic figure to his great Speculum; a point of perfection that Gregory and Newton had wished for, but despaired of attaining; and that Hadley had never, as far as we know, attempted, either in his Newtonian or Gregorian telescope. Mr Short indeed said he had acquired that faculty, but never would tell by what peculiar means he effected it; so that the secret of working that configuration, whatever it was, as far as it then appeared, died with that ingenious artist. Mr Mudge, however, hath lately realised the expectation of Sir Isaac Newton, who, above 100 years ago, presaged that the public would one day possess a parabolic Speculum, not accomplished by mathematical rules, but by mechanical devices.

This was a *desideratum*, but it was not the only want supplied by this gentleman: he has taught us likewise a better composition of metals for the Specula, how to grind them better, and how to give them a finer polish; and this last part, (namely, the polish), he remarks, was the most difficult and essential of the whole operation. "In a word (says Sir John Pringle), I am of opinion, there is no optician in this great city (which hath been so long and so justly renowned for ingenious and dexterous makers of every kind of mathematical instruments) so partial to his own abilities

as not to acknowledge, that, however some parts of the mechanical process now disclosed might have been known before by individuals of the profession, yet that Mr Mudge hath opened to them all some new and important lights, and upon the whole hath greatly improved the art of making reflecting telescopes."

98

Mr Edwards's improvements of the reflecting telescope.

The late reverend and ingenious John Edwards devoted much of his time to the improvement of reflecting telescopes, and brought them to such perfection, that Dr Maskelyne, the astronomer royal, found telescopes constructed by him to surpass in brightness, and other essentials, those of the same size made by the best artists in London. The chief excellence of his telescopes arises from the composition, which, from various trials on metals and semimetals, he discovered for the specula, and from the true parabolic figure, which, by long practice, he had found a method of giving them, preferable to any that was known before him. His directions for the composition of specula, and for casting, grinding, and polishing them, were published, by order of the commissioners of longitude, at the end of the Nautical Almanack for the year 1787. To the same almanack is also annexed his account of the cause and cure of the tremors which particularly affect reflecting telescopes more than refracting ones, together with remarks on the said tremors by Dr Maskelyne. See TELESCOPE.

99

Herschel's improvements.

But in constructing reflecting telescopes of extraordinary magnifying powers, Dr Herschel has displayed skill and ingenuity surpassing all his predecessors in this department of mechanics. He has made them from 7, 10, 20, to even 40 feet in length; and with the instrument of these latter dimensions he is now employed in making discoveries in astronomy. Of its construction, magnifying powers, and the curious collection of machinery by which it is supported and moved from one part of the heavens to another, accounts will be given under the word TELESCOPE.

The greatest improvement in *refracting* telescopes hitherto made public (c) is that of Mr Dollond, of which an account has already been given in a preceding section, wherein his discoveries in the science of Optics were explained. But, besides the obligation we are under to him for correcting the aberration of the rays of light in the focus of object-glasses, arising from their different refrangibility, he made another considerable improvement in telescopes, viz. by correcting, in a great measure, both this kind of aberration, and also that which arises from the spherical form of lenses, by an expedient of a very different nature; viz. increasing the number of eye-glasses.

100

Account of Mr Dollond's improvements

If any person, says he, would have the visual angle of a telescope to contain 20 degrees, the extreme pencils of the field must be bent or refracted in an angle of 10 degrees; which, if it be performed by one eye-glass, will cause an aberration from the figure, in proportion to the cube of that angle; but if two glasses are so proportioned and situated, as that the refraction may be equally divided between them, they will each of them produce a refraction equal to half the required angle; and therefore, the aberration being in proportion to the cube of half the angle taken twice over, will be but a fourth part of that which is in proportion to the cube of the whole angle; because twice the cube of 1 is but $\frac{1}{4}$ of the cube of 2; so the aberration from the figure, where two eye-glasses are rightly proportioned, is but a fourth of what it must unavoidably be, where the whole is performed by a single eye-glass. By the same way of reasoning, when the refraction is divided between three glasses, the aberration will be found to be but the ninth part of what would be produced from a single glass; because three times the cube of 1 is but one-ninth of the cube of 3. Whence it appears, that by increasing the number of eye-glasses, the indistinctness which is observed near the borders of the field of a telescope may be very much diminished, though not entirely taken away.

The method of correcting the errors arising from the different refrangibility of light is of a different consideration from the former. For, whereas the errors from the figure can only be diminished in a certain proportion according to the number of glasses, in this they may be entirely corrected by the addition of only one glass; as we find in the astronomical telescope, that two eye-glasses, rightly proportioned, will cause the edges of objects to appear free from colours, quite to the borders of the field. Also in the day-telescope, where no more than two eye-glasses are absolutely necessary for erecting the object, we find, that by the addition of a third, rightly situated, the colours, which would otherwise make the image confused, are entirely removed. This, however, is to be understood with some limitation: for though the different colours into which the extreme pencils must necessarily be divided by the edges of the eye-glasses, may in this manner be brought to the eye in a direction parallel to each other, so as, by the humours of the eye, to be made to converge to a point on the retina; yet, if the glasses exceed a certain length, the colours may be spread too wide to be capable of being admitted through the pupil or aperture of the eye; which is the reason, that in long telescopes, constructed in the common manner, with three eye-glasses, the field is always very much contracted.

These considerations first set Mr Dollond on contriving how to enlarge the field, by increasing the number of eye-glasses without any hinderance to the distinctness or brightness of the image; and though others had been about the same work before, yet, observing that some five-glass telescopes which were then made would admit of farther improvement, he endeavoured to construct one with the same number of glasses in a

M m better

(c) Dr Blair's discovery, mentioned n^o 19, will undoubtedly lead to improvements superior to those of Dollond; but as his memoir on the subject is not yet published, we feel not ourselves at liberty to make longer extracts from it. The reader will see the whole in the Philosophical Transactions of the Royal Society of Edinburgh, whenever that body shall be pleased to favour the public with a third volume of its learned labours.

better manner; which so far answered his expectations, as to be allowed by the best judges to be a considerable improvement on the former.

Encouraged by this success, he resolved to try if he could not make some farther enlargement of the field, by the addition of another glass, and by placing and proportioning the glasses in such a manner as to correct the aberrations as much as possible, without any detriment to the distinctness; and at last he obtained as large a field as is convenient or necessary, and that even in the longest telescopes that can be made.

These telescopes with six glasses having been well received, and some of them being gone into foreign parts, it seemed a proper time to the author to settle the date of his invention; on which account he drew up a letter, which he addressed to Mr Short, and which was read at the Royal Society, March 1. 1753 (D).

101
Mr Smith's
proposal to
shorten te-
lescopes.

Various other attempts were made about this time to shorten and otherwise improve telescopes. Among these we must just mention that of Mr Caleb Smith, who, after giving much attention to the subject, thought that he had found it possible to rectify the errors which arise from the different degrees of refrangibility, on the principle that the sines of refraction, or rays differently refrangible, are to one another in a given proportion, when their sines of incidence are equal; and the method which he proposed for this purpose was to make the speculums of glass instead of metal, the two surfaces having different degrees of concavity. But we do not find that his scheme was ever executed; nor is it probable, for reasons which have been mentioned, that any advantage could be made of it.

102
Equatorial
telescope,
or portable
observa-
tory.

To Mr Short we are indebted for the excellent contrivance of an equatorial telescope, or, as he likewise called it, a *portable observatory*; for with it pretty accurate observations may be made with very little trouble, by those who have no building adapted to the purpose. The instrument consists of an ingenious piece of machinery, by the help of which a telescope mounted upon it may be directed to any degree of right ascension or declination, so that the place of any of the heavenly bodies being known, they may be found without any trouble, even in the day-time. Also, being made to turn parallel to the equator, any object is easily kept in view, or recovered, without moving the eye from its situation. By this instrument, Mr Short informs us, that most of the stars of the first and second magnitude have been seen even at mid-day, and the sun shining bright; as also Mercury, Venus, and Jupiter. Saturn and Mars are not so easy to be seen, on account of the faintness of their light, except when the sun is but a few hours above the horizon. This particular effect depends upon the telescope excluding almost all the light, except what comes from the object itself, and which might otherwise efface the impression made by its weaker light upon the eye. Any telescope of the same magnifying power would have the same effect, could we be sure of pointing it right. For the same reason, also, it is that stars are visible in the day-time from the bottom of a deep pit. Mr Ramsden has lately invented a *portable observatory* or *equatorial telescope*, which may perhaps

superfede the use of Mr Short's. See ASTRONOMY, n^o 504.

103
How to ob-
serve the
stars in the
day time.
In order to enable us to see the fixed stars in the day-time, it is necessary to exclude the extraneous light as much as possible. For this reason the greater magnifying power of any telescope is used, the more easily a fixed star will be distinguished in the day-time; the light of the star remaining the same in all magnifying powers of the same telescope, but the ground upon which it is seen becoming darker by increasing the magnifying power; and the visibility of a star depends very much upon the difference between its own light and that of the ground upon which it is seen. A fixed star will be very nearly equally visible with telescopes of very different apertures, provided the magnifying power remains the same.

If a comet, or any other heavenly body, be viewed through this equatorial telescope, properly rectified, it is seen immediately by the help of the same machinery what is its true place in the heavens. Other astronomical problems may also be solved by it, with great ease and certainty.

104
Mr Epi-
nus's pro-
posal for
bending the
tubes of te-
lescopes.
M. Æpinus proposes to bend the tubes of long telescopes at right angles, fixing a plane mirror in the angle, in order to make them more commodious for viewing objects near the zenith of the observer; and he gives particular instructions how to make them in this form, especially when they are furnished with micrometers. We are also informed that a little plane speculum is sometimes placed betwixt the last eye-glass and the eye in the reflecting telescopes, at an angle of 45°, for the same purpose.

The invention of MICROSCOPES was not much later than that of telescopes; and, according to Borellus, whose account we do not find to have been called in question by any person, we are indebted for them to the same author, at least to Z. Jansen, in conjunction with his son; and for this latter favour we may, perhaps, be considered as under more obligation to them than for the former, the microscope having more various and extensive uses, with respect to philosophy, than the telescope. In our ideas, however, it appears something greater, and more extraordinary, to be able to see objects too distant to be perceived by the naked eye, than those that are too near to be seen by us; and therefore there is more of the sublime in the telescope than the microscope. These two instruments, though different in their application, are notwithstanding very similar; as both of them assist us in the discovery of objects that we must otherwise have remained unacquainted with, by enlarging the angle which they subtend at the eye.

105
History of
microscopes

The Jansens, however, have not always enjoyed, undisturbed, that share of reputation to which they seem to be intitled, with respect either to the telescope or the microscope. The discovery of the latter, in particular, has generally been considered as more uncertain than that of the former. All that many writers say we can depend upon is, that microscopes were first used in Germany about the year 1621. Others say positively, that this instrument was the contrivance of

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(D) This paragraph is extracted from this paper in the Transactions; but Dollond's improvement, there described, is not accompanied by any diagram. For a minute account of it, and of eye-pieces in general, see *Ludlam's Essays*.

Cornelius Drebell, no philosopher, but a man of curiosity and ingenuity, who also invented the thermometer.

According to Borellus, Zacharias Jansen and his son presented the first microscopes they had constructed to prince Maurice, and Albert archduke of Austria. William Borell, who gives this account in a letter to his brother Peter, says, that when he was ambassador in England, in 1619, Cornelius Drebell, with whom he was intimately acquainted, showed him a microscope, which he said was the same the archduke had given him, and had been made by Jansen himself. This instrument was not so short as they are generally made at present, but was six feet long, consisting of a tube of gilt copper, an inch in diameter, supported by three brass pillars in the shape of dolphins, on a base of ebony, on which the small objects were placed.

106
Microscope
made by
Jansen.

This microscope was evidently a compound one, or rather something betwixt a telescope and a microscope, what we should now, perhaps, choose to call a *megascop*; so that it is possible that single microscopes might have been known, and in use, some time before: but perhaps nobody thought of giving that name to single lenses; though, from the first use of lenses, they could not but have been used for the purpose of magnifying small objects. In this sense we have seen, that even the ancients were in possession of microscopes; and it appears from Jamblicus and Plutarch, quoted by Dr Rogers, that they gave such instruments as they used for this purpose the name of *dioptra*. As spectacles were certainly in use long before the invention of telescopes, one can hardly help concluding, that lenses must have been made smaller, and more convex, for the purpose of magnifying minute objects; especially as the application of this kind of microscope was nearly the same with that of a spectacle-glass, both of them being held close to the eye. At what time lenses were made so small as we now generally use them for magnifying in single microscopes, we have not found. But as this must necessarily have been done gradually, the only proper object of inquiry is the invention of the double or compound microscope; and this is clearly given, by the evidence of Borellus above-mentioned, to Zacharias Jansen, the inventor of the telescope, or his son.

The invention of compound microscopes is claimed by the same Fontana who claimed the discovery of telescopes; and though he did not publish any account of this invention till the year 1646 (notwithstanding he pretended to have made the discovery in 1618), Montucla, not having attended perhaps to the testimony of Borellus, is willing to allow his claim, as he thought there was no other person who seemed to have any better right to it.

107
By Divini.

Eustachio Divini made microscopes with two common object-glasses, and two plano-convex eye-glasses joined together on their convex sides so as to meet in a point. The tube in which they were inclosed was as big as a man's leg, and the eye-glasses almost as broad as the palm of a man's hand. Mr Oldenburg, secretary to the royal society, received an account of this instrument from Rome, and read it at one of their meetings, August 6. 1668.

108
By Hart-
tucker.

It was in this period that Harttucker improved single microscopes, by using small globules of glass, made by melting them in the flame of a candle, in-

stead of the lenses which had before been made use of for that purpose. By this means he first discovered the *animalcula in semine masculino*, which gave rise to a new system of generation. A microscope of this kind, consisting of a globule of $\frac{1}{10}$ of an inch in diameter, M. Huygens demonstrated to magnify 100 times; and since it is easy to make them of less than half a line in diameter, they may be made to magnify 300 times. Were it not for the difficulty of applying objects to these magnifiers, the want of light, and the small field of distinct vision, they would certainly have been the most perfect of all microscopes.

But no man distinguished himself so much by microscopical discoveries as the famous M. Leeuwenhoek, though he used only single lenses with short foci, preferring distinctness of vision to a large magnifying power.

109
By Leeu-
wenhoek.

M. Leeuwenhoek's microscopes were all single ones, each of them consisting of a small double convex-glass, set in a socket between two silver plates rivetted together, and pierced with a small hole; and the object was placed on the point of a needle, so contrived as to be placed at any distance from the lens. If the objects were solid, he fastened them with glue; and if they were fluid, or on other accounts required to be spread upon glass, he placed them on a small piece of Muscovy talc, or glass blown very thin; which he afterwards glued to his needle. He had, however, a different apparatus for viewing the circulation of the blood, which he could fix to the same microscopes.

The greatest part of his microscopes M. Leeuwenhoek bequeathed to the Royal Society. They were contained in a small Indian cabinet, in the drawers of which were 13 little boxes, or cases, in each of which were two microscopes, neatly fitted up in silver; and both the glass and the apparatus were made with his own hands.

The glass of all these lenses is exceedingly clear, but none of them magnifies so much as those globules which are frequently used in other microscopes; but Mr Folkes, who examined them, thought that they showed objects with much greater distinctness, which M. Leeuwenhoek principally valued. His discoveries, however, are to be ascribed not so much to the goodness of his glasses, as to his great judgment, acquired by long experience, in using them. He also particularly excelled in his manner of preparing objects for being viewed to the most advantage.

Mr Baker, who also examined M. Leeuwenhoek's microscopes, and made a report concerning them to the Royal Society, found that the greatest magnifier among them enlarged the diameter of an object about 160 times, but that all the rest fell much short of that power; so he concluded that M. Leeuwenhoek must have had other microscopes of a much greater magnifying power for many of his discoveries. And it appears, he says, by many circumstances, that he had such microscopes.

It appears from M. Leeuwenhoek's writings, that he was not unacquainted with the method of viewing opaque objects by means of a small concave reflecting mirror, which was afterwards improved by M. Lieberkhun. For, after describing his apparatus for viewing eels in glass tubes, he adds, that he had an instrument to which he screwed a microscope set in brass,

M m 2

upon

upon which microscope he fastened a little dish of brass, probably that his eye might be thereby assisted to see objects better; for he says he had filed the brass which was round his microscope as bright as he could, that the light, while he was viewing objects, might be reflected from it as much as possible. This microscope, with its dish, is constructed upon principles so similar to those which are the foundation of our single microscope by reflection (see MICROSCOPE), that it may well be supposed to have given the hint to the ingenious inventor of it, provided he ever attended to it.

110
Wilson's
microscope.

In 1702, Mr Wilson made several ingenious improvements in the method of using single magnifiers, for the purpose of viewing transparent objects; and his microscope, which is also a necessary part of the solar microscope, is in very general use at this day. (See MICROSCOPE, sect. 1.)

111
Adams's
method of
making glo-
bules for
large mag-
nifiers.

In 1710, Mr Adams gave to the Royal Society the following account of his method of making small globules for large magnifiers. He took a piece of fine window-glass, and cut it with a diamond into as many lengths as he thought proper, not exceeding $\frac{1}{8}$ of an inch in breadth; then, holding one of them between the fore-finger and thumb of each hand over a very fine flame, till the glass began to soften, he drew it out till it was as fine as a hair, and broke; then putting each of the ends into the purest part of the flame, he had two globules presently, which he could make larger or less at pleasure. If they were held a long time in the flame, they would have spots in them, so that he drew them out presently after they became round. The stem he broke off as near to the globule as he could, and lodging the remainder between the plates, in which holes were drilled exactly round, the microscope, he says, performed to admiration. Thro' these magnifiers, he says, that the same thread of very fine muslin appeared three or four times bigger than it did in the largest of Mr Wilson's magnifiers.

112
Temporary
microscopes
by Mr
Grey.

The ingenious Mr Grey hit upon a very easy expedient to make very good temporary microscopes, at a very little expence. They consist of nothing but very small drops of water, taken up with a point of a pin, and put into a small hole made in a piece of metal. Those globules of water do not, indeed, magnify so much as those which are made of glass of the same size, because the refractive power of water is not so great; but the same purpose will be answered nearly as well by making them somewhat smaller.

The same ingenious person, observing that small heterogeneous particles inclosed in the glass of which microscopes are made, were much magnified when those glasses were looked through, thought of making his microscopes of water that contained living animalcula, to see how they would look in this new situation; and he found his scheme to answer even beyond his utmost expectation, so that he could not even account for their being magnified so much as they were: for it was much more than they would have been magnified if they had been placed beyond the globule, in the proper place for viewing objects. But Montucla observes, that, when any object is inclosed within this small transparent globule, the hinder-part of it acts like a concave mirror, provided they be situated between that surface and the focus; and that, by this means, they

are magnified above $3\frac{1}{2}$ times more than they would have been in the usual way.

After the happy execution of the reflecting telescope, it was natural to expect that attempts would also be made to render a similar service to microscopes. Accordingly we find two plans of this kind. The first was that of Dr Robert Barker. His instrument differs in nothing from the reflecting telescope, excepting the distance of the two speculums, in order to adapt it to those pencils of rays which enter the microscope diverging; whereas they come to the telescope from very distant objects nearly parallel to each other.

This microscope is not so easy to manage as the common sort. For vision by reflection, as it is much more perfect, so it is far more difficult than that by refraction. Nor is this microscope so useful for any but very small or transparent objects. For the object, being between the speculum and image, would, if it were large and opaque, prevent a due reflection.

Dr Smith invented a double reflecting microscope, of which a theoretical and practical account is given in the remarks on the second volume of his System of Optics. Through some of those incidents to which the conducting of a work so multifarious as ours is always liable, this instrument was omitted under the article MICROSCOPE. As it is constructed on principles essentially different from all others, and, in the opinion of the ablest judges whom we have consulted, incomparably superior to them all, the reader will not be ill pleased with the following practical description, though it appears not perhaps in its most proper place.

Fig. 2. is a section of this microscope, where ABC and abc are two specula, the former concave, and the latter convex, inclosed within the tube DEFG. The speculum ABC, is perforated like the speculum of a Gregorian telescope; and the object to be magnified is so placed between the centre and principal focus of that speculum, that the rays flowing from it to ABC are reflected towards an image pq. But before they are united in that image they are received by the convex speculum abc, and thence reflected through the hole BC in the vertex of the concave to a second image xx, to be viewed through an eye-glass l. The object may either be situated between the two specula, or, which is perhaps better, between the principal focus and vertex c of the convex speculum abc, a small hole being made in its vertex for the incident rays to pass through. When the microscope is used, let the object be included between two little round plates of Moscow-glass, fixed in a hole of an oblong brass plate mn, intended to slide close to the back side of the convex speculum; which must therefore be ground flat on that side, and so thin that the object may come precisely to its computed distance from the vertex of the speculum. The slider must be kept tight to the back of the metal by a gentle spring. The distance of the object being thus determined once for all, distinct vision to different eyes, and through different eye-glasses, must be procured by a gentle motion of the little tubes that contain these glasses. These tubes must be made in the usual form of those that belong to Sir Isaac Newton's reflecting telescope, (see TELESCOPE), having a small hole in the middle of each plate, at the ends of the tube, situated exactly in each focus of the

Plate
CCCLIV.

glass: the use of these holes and plates is to limit the visible area, and hinder any straggling rays from entering the eye. To the tube of the eye-glass is fastened the arm *g*, on which the adjusting screw turns. A similar arm *u* is attached to the fixed tube *X*, in which the neck of the screw turns; and by turning the button *y*, the eye tube is moved farther from or nearer to the object, by which means different sorts of eyes obtain distinct vision.

The rays which flow from the object directly thro' the hole in the concave speculum and through the eye-glass, by mixing with the reflected rays, would dilute the image on the retina, and therefore must be intercepted. This is done by a very simple contrivance. The little hole in the convex speculum is ground conical as in the figure; and a conical solid *P*, of which the base is larger than the orifice in the back of the convex speculum, supported on the slender pillar *PQ*, is so placed as to intercept all the *direct* rays from the eye-glass. All the tubes are strongly blacked on their insides, and so is the conical solid, to hinder all reflection of rays from these objects upon the convex speculum. The little base, too, of the solid should be made concave, that whatever light it may still reflect, may be thrown back upon the object; and its back-side being conical and blacked all over, will either absorb or laterally disperse any straggling rays which the concave speculum may scatter upon it, and so prevent their coming to the eye-glass.

Notwithstanding the interposition of this conical solid, yet when the eye-glass is taken out, distant objects may be distinctly seen through the microscope, by rays reflected from the metals, and diverging upon the eye from an image behind the convex speculum. But this mixture of foreign rays with those of the object, which is common to all kinds of microscopes in viewing transparent objects, is usually prevented by placing before the object a thick double convex lens *L*, to collect the sky-light exactly upon the object. This lens should be just so broad as to subtend the opposite angle to that which the concave speculum subtends at the object. The annular frame of the lens must be very narrow, and connected to the microscope by two or three slender wires or blades, whose planes produced may pass through the object, and intercept from it as little sky-light as possible.

This is not the place for explaining the principles of this microscope, or demonstrating its superiority over most others; nor are such explanation and demonstration necessary. Its excellence, as well as the principles upon which it is constructed, will be perceived by the reader, when he has made himself master of the laws of refraction and reflection as laid down in the ensuing part of this article.

115
Solar microscope, and that for opaque objects.

In 1738 or 1739, M. Lieberkuhn made two capital improvements in microscopes, by the invention of the *solar microscope*, and the *microscope for opaque objects*. When he was in England in the winter of 1739, he showed an apparatus of his own making, for each of these purposes, to several gentlemen of the Royal Society, as well as to some opticians, particularly Mr Cuff in Fleet-street, who took great pains to improve them.

The microscope for opaque objects remedies the inconvenience of having the dark side of an object next

the eye. For by means of a concave speculum of silver, highly polished, in the centre of which a magnifying lens is placed, the object is so strongly illuminated that it may be examined with all imaginable ease and pleasure. A convenient apparatus of this kind, with four different speculums and magnifiers of different powers, was brought to perfection by Mr Cuff.

M. Lieberkuhn made considerable improvements in his solar microscope, particularly in adapting it to the view of opaque objects; but in what manner this end was effected, M. Æpinus, who was highly entertained with the performance, and who mentions the fact, was not able to recollect; and the death of the ingenious inventor prevented his publishing any account of it himself. M. Æpinus invites those persons who came into the possession of M. Lieberkuhn's apparatus to publish an account of this instrument; but it doth not appear that his method was ever published.

This improvement of M. Lieberkuhn's induced M. Æpinus himself to attend to the subject; and by this means he produced a very valuable improvement in this instrument. For by throwing the light upon the fore-side of any object by means of a mirror, before it is transmitted through the object-lens, all kinds of objects are equally well represented by it.

116
Reflected light introduced into the microscope and magic lantern.

M. Euler proposed a scheme to introduce vision by reflected light into the magic lantern and solar microscope, by which many inconveniences to which those instruments are subject might be avoided. For this purpose, he says, that nothing is necessary but a large concave mirror, perforated as for a telescope; and that the light be so situated, that none of it may pass directly through the perforation, so as to fall on the images of the objects upon the screen. He proposes to have four different machines, for objects of different sizes; the first for those of six feet long, the second for those of one foot, the third for those of two inches, and the fourth for those of two lines; but it is needless to be particular in the description of these, as more perfect instruments are described under the article MICROSCOPE.

Several improvements were made in the apparatus to the solar microscope, as adapted to view opaque objects, by M. Zeiher, who made one construction for the larger kind of objects, and another for the small ones.

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Mr Martin's improvement in the solar microscope.

Mr Martin having constructed a solar microscope of a larger size than common, for his own use, the illuminating lens being $4\frac{1}{2}$ inches in diameter, and all the other parts of the instrument in proportion, found, that by the help of an additional part, which he does not describe, he could see even opaque objects very well. If he had made the lens any larger, he was aware that the heat produced at the focus would have been too great for the generality of objects to bear. The expence of this instrument, he says, does not much exceed the price of the common solar microscope.

118
Di Torre's extraordinary magnifying microscope.

The smallest globules, and consequently the greatest magnifiers, for microscopes, that have yet been executed, were made by T. Di Torre of Naples, who, in 1765, sent four of them to the Royal Society. The largest of them was only two Paris points in diameter, and it was said to magnify the diameter of an object 640 times. The second was the size of one Paris point,

and

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Could not
be used by
Mr Baker

and the third was no more than half of a Paris point, or the 144th part of an inch in diameter, and was said to magnify the diameter of an object 2560 times. One of these globules was wanting when they came into the hands of Mr Baker, to whose examination they were referred by the Royal Society. This gentleman, so famous for his skill in microscopes, and his extraordinary expertness in managing them, was not able to make any use of these. With that which magnifies the least, he was not able to see any object with satisfaction; and he concludes his account with expressing his hopes only, that, as his eyes had been much used to microscopes, they were not injured by the attention he had given to them, though he believed there were few persons who would not have been blinded by it.

The construction of a telescope with six eye-glasses led M. Euler to a similar construction of microscopes, by introducing into them six lenses, one of which admits of so small an aperture, as to serve, instead of a

diaphragm, to exclude all foreign light, though, as he says, it neither lessens the field of view, nor the brightness of objects.

The improvement of all dioptric instruments is greatly impeded by inequalities in the substance of the glass of which they are made; but though many attempts have been made to make glass without that imperfection, none of them have been hitherto quite effectual. M. A. D. Merklein, having found some glass which had been melted when a building was on fire, and which proved to make excellent object glasses for telescopes, concluded that its peculiar goodness arose from its not having been disturbed when it was in a fluid state; and therefore he proposed to take the metal out of the furnace in iron vessels, of the same form that was wanted for the glass; and after it had been perfectly fluid in those vessels, to let it stand to cool, without any disturbance. But this is not always found to answer.

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Difficulties
attending
the construction of
dioptric instruments.

PART I. THEORY OF OPTICS.

THIS part of the science contains all that hath been discovered concerning the various motions of the rays of light, either through different mediums, or when reflected from different substances in the same medium. It contains also the *rationale* of every thing which hath been discovered with regard to vision; the optical deceptions to which we are liable; and, in short, ought to give the reason of all the known optical phenomena.—The science is commonly divided into three parts, *viz.* dioptrics, which contains the laws of refraction, and the phenomena depending upon them; catoptrics, which contains the laws of reflection, and the phenomena which depend on them; and, lastly, chromatics, which treat of the phenomena of colour. But this definition is of no use in a treatise of Optics, as most of the phenomena depend both on refraction and reflection, colour itself not excepted. For this reason, though we have given detached articles under the words **DIOPTRICS**, **CATOPTRICS**, and **CHROMATICS**; we have reserved to this place the explanation of the laws of reflection and refraction, by which all optical phenomena may be accounted for.

SECT. I. *Of the properties of Light in general.*

UNDER the article **LIGHT** we have given some account of the controversies concerning its nature. The opinions of philosophers may, in general, be arranged under these two: 1. That the phenomena of vision and illumination are produced by the undulations of an elastic fluid, much in the same manner as sound is produced by the undulations of air. This opinion was first offered to the public by Des Cartes, and afterwards by Mr Huyghens, and has lately been revived by Mr Euler, who has endeavoured to explain the phenomena upon mechanical principles.—2d, That the phenomena of vision are produced by the motion and action of matter emitted from the shining body with immense velocity, moving uniformly in straight lines, and acted on by other bodies; so as to be reflected, refracted, or inflected, in various ways, by means of forces which

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Different
opinions
concerning
the nature
of light.

act on it in the same manner as on other inert matter. Sir Isaac Newton has shown, in the most incontrovertible manner, the total dissimilarity between the phenomena of vision and the legitimate consequences of the undulations of an elastic fluid. All Mr Euler's ingenious and laborious discussions have not removed Newton's objections in the smallest degree. Sir Isaac adopts the vulgar opinion, therefore, making light of the difficulties objected to it, because none of them are inconsistent with the established principles of mechanics, and are merely difficulties of conception to limited faculties like ours. We need not despair of being able to decide, by experiment, which of these opinions is nearest to the truth; because there are phenomena where the result should be sensibly different in the two hypotheses. At present, we shall content ourselves with giving some account of the legitimate consequences of the vulgar opinion as modified by Sir Isaac Newton, *viz.* that light consists of small particles emitted with very great velocity, and attracted or repelled by other bodies at very small distances.

Every visible body emits or reflects inconceivably small particles of matter from each point of its surface, which issue from it continually (not unlike sparks from a coal) in straight lines and in all directions. These particles entering the eye, and striking upon the retina (a nerve expanded on the back part of the eye to receive their impulses), excite in our minds the idea of light. And as they differ in substance, density, velocity, or magnitude, they produce in us the ideas of different colours; as will be explained in its proper place.

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Light issues
in straight
lines from
each point
in a luminous
surface.

That the particles which constitute light are exceedingly small, appears from hence, *viz.* that if a hole be made through a piece of paper with a needle, rays of light from every object on the farther side of it are capable of passing through it at once without the least confusion; for any one of those objects may as clearly be seen through it, as if no rays passed through it from any of the rest. Further, if a candle is lighted, and there be no obstacle in the way to obstruct the progress

Refraction. greffs of its rays, it will fill all the space within two miles of it every way with luminous particles, before it has lost the least sensible part of its substance thereby.

That these particles proceed from every point of the surface of a visible body, and in all directions, is clear from hence, *viz.* because wherever a spectator is placed with regard to the body, every point of that part of the surface which is turned towards him is visible to him. That they proceed from the body in right lines, we are assured, because just so many and no more will be intercepted in their passage to any place by an interposed object, as that object ought to intercept, supposing them to come in such lines.

The velocity with which they proceed from the surface of the visible body is no less surprising than their minuteness: the method whereby philosophers estimate their swiftness, is by observations made on the eclipses of Jupiter's satellites; which eclipses to us appear about seven minutes sooner than they ought to do by calculation, when the earth is placed between the sun and him, that is, when we are nearest to him; and as much later, when the sun is between him and us, at which time we are farthest from him; from whence it is concluded, that they require about seven minutes to pass over a space equal to the distance between the sun and us, which is about 95,000,000 of miles.

A stream of these particles issuing from the surface of a visible body in one and the same direction, is called a *ray of light*.

As rays proceed from a visible body in all directions, they necessarily become thinner and thinner, continually spreading themselves as they pass along into a larger space, and that in proportion to the squares of their distances from the body; that is, at the distance of two spaces, they are four times thinner than they are at one; at the distance of three spaces, nine times thinner, and so on: the reason of which is, because they spread themselves in a twofold manner, *viz.* upwards and downwards, as well as sideways.

The particles of light are subject to the laws of attraction of cohesion, like other small bodies; for if a ray of light be made to pass by the edge of a knife, it will be diverted from its natural course, and be inflected towards the edge of the knife. The like inflection happens to a ray when it enters obliquely into a denser or rarer substance than that in which it was before, in which case it is said to be refracted; the laws of which refraction are the subject of the following section.

SECT. II. Of Refraction.

¹²³
Refraction
defined.

LIGHT, when proceeding from a luminous body, without being reflected from any opaque substance, or inflected by passing very near one, is invariably found to proceed in straight lines, without the least deviation. But if it happens to pass obliquely from one medium to another, it always leaves the direction it had before, and assumes a new one; and this change of course is called its *refraction*. After having taken this new direction, it then proceeds invariably in a straight line till it meets with a different medium, when it is again turned out of its course. It must be observed, however, that though by this means we may cause the rays

of light make any number of angles in their course, it is impossible for us to make them describe a curve, except in one single case, namely, where they pass through a medium, the density of which uniformly either increases or decreases. This is the case with the light of the celestial bodies, which passes downwards through our atmosphere, and likewise with that which is reflected upwards through it by terrestrial objects. In both these cases, it describes a curve of the hyperbolic kind; but at all other times it proceeds in straight lines, or in what may be taken for straight lines without any sensible error.

§ 1. The cause of Refraction, and the law by which it is performed.

THE phenomena of refraction are explained by an attractive power in the medium through which light passes, in the following manner: All bodies being endowed with an attractive force, which is extended to some distance beyond their surfaces; when a ray of light passes out of a rarer into a denser medium (if this latter has a greater attractive force than the former, as is commonly the case), the ray, just before its entrance, will begin to be attracted towards the denser medium; and this attraction will continue to act upon it, till some time after it has entered the medium; and therefore, if a ray approaches a denser medium in a direction perpendicular to its surface, its velocity will be continually accelerated during its passage through the space in which that attraction exerts itself; and therefore, after it has passed that space, it will move on, till it arrives at the opposite side of the medium, with a greater degree of velocity than it had before it entered. So that in this case its velocity only will be altered. Whereas, if a ray enters a denser medium obliquely, it will not only have its velocity augmented thereby, but its direction will become less oblique to the surface. Just as when a stone is thrown downwards obliquely from a precipice, it falls to the surface of the ground in a direction nearer to a perpendicular one, than that with which it was thrown from the hand. From hence we see a ray of light, in passing out of a rarer into a denser medium, is refracted towards the perpendicular; that is, supposing a line drawn perpendicularly to the surface of the medium, through the point where the ray enters, and extended both ways, the ray in passing through the surface is refracted or bent towards the perpendicular line; or, which is the same thing, the line which it describes by its motion after it has passed through the surface, makes a less angle with the perpendicular, than the line it described before. All which may be illustrated in the following manner.

Let us suppose first, that the ray passes out of a vacuum into the denser medium ABCD (fig. 3.), and that the attractive force of each particle in the medium is extended from its respective centre to a distance equal to that which is between the lines AB and EF, or AB and GH; and let KL be the path described by a ray of light in its progress towards the denser medium. This ray, when it arrives at L, will enter the attractive forces of those particles which lie in AB the surface of the denser medium, and will therefore cease to proceed any longer in the right line KLM, but will be diverted from its course by being attracted towards

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the

Cause of Refraction.

the line AB, and will begin to describe the curve I.N, passing through the surface AB in some new direction, as OQ; thereby making a less angle with a line, as PR, drawn perpendicularly through the point N, than it would have done had it proceeded in its first direction KLM.

Farther: Whereas, we have supposed the attractive force of each particle to be extended through a space equal to the distance between AB and EF, it is evident that the ray, after it has entered the surface, will still be attracted downwards, till it has arrived at the line EF; for, till that time, there will not be so many particles above it which will attract it upwards, as below, that will attract it downwards. So that after it has entered the surface at N, in the direction OQ, it will not proceed in that direction, but will continue to describe a curve, as NS; after which it will proceed straight on towards the opposite side of the medium, being attracted equally every way; and therefore will at last proceed in the direction XST, still nearer the perpendicular PR than before.

Now if we suppose ABZY not to be a vacuum, but a rarer medium than the other, the case will still be the same; but the ray will not be so much refracted from its rectilineal course, because the attraction of the particles of the upper medium being in a contrary direction to that of the attraction of those in the lower one, the attraction of the denser medium will in some measure be destroyed by that of the rarer.

On the contrary, when a ray passes out of a denser into a rarer medium, if its direction be perpendicular to the surface of the medium, it will only lose somewhat of its velocity, in passing through the spaces of attraction of that medium (that is, the space wherein it is attracted more one way than it is another). If its direction be oblique, it will continually recede from the perpendicular during its passage, and by that means have its obliquity increased, just as a stone thrown up obliquely from the surface of the earth increases its obliquity all the time it rises. Thus, supposing the ray TS passing out of the denser medium ABCD into the rarer ABZY, when it arrives at S it will begin to be attracted downwards, and so will describe the curve SNL, and then proceed in the right line LK; making a larger angle with the perpendicular PR, than the line TSX in which it proceeded during its passage through the other medium.

We may here make a general observation on the forces which produce this deviation of the rays of light from their original path. They arise from the joint action of all the particles of the body which are sufficiently near the particle of light; that is, whose distance from it is not greater than the line AE or GA; and therefore the whole force which acts on a particle in its different situations between the planes GH and EF, follows a very different law from the force exerted by one particle of the medium.

The space through which the attraction of cohesion of the particles of matter is extended is so very small, that in considering the progress of a ray of light out of one medium into another, the curvature it describes in passing through the space of attraction is generally neglected; and its path is supposed to be bent, or, in the usual terms, the ray is supposed to be refracted only in the point where it enters the denser medium.

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Cause of Refraction.

Now the line which a ray describes before it enters a denser or a rarer medium, is called the *incident ray*; that which it describes after it has entered, is the *refracted ray*.

The angle comprehended between the incident ray and the perpendicular, is the *angle of incidence*; and that between the refracted ray and the perpendicular, is the *angle of refraction*.

There is a certain and immutable law or rule, by which refraction is always performed; and that is this: Whatever inclination a ray of light has to the surface of any medium before it enters it, the degree of refraction will always be such, that the proportion between the sine of the angle of its incidence, and that of the angle of its refraction, will always be the same in that medium.

To illustrate this: Let us suppose ABCD (fig. 4.) to represent a rarer, and ABEF a denser medium: let GH be a ray of light passing through the first and entering the second at H, and let HI be the refracted ray: then supposing the perpendicular PR drawn thro' the point H, on the centre H, and with any radius, describe the circle APBR; and from G and I, where the incident and refracted rays cut the circle, let fall the lines GK and IL perpendicularly upon the line PR; the former of these will be the sine of the angle of incidence, the latter of refraction. Now if in this case the ray GH is so refracted at H, that GK is double or triple, &c. of IL, then, whatever other inclination the ray GH might have had, the sine of its angle of incidence would have been double or triple, &c. to that of its angle of refraction. For instance, had the ray passed in the line MH before refraction, it would have passed in some line as HN afterwards, so situated that MO should have been double or triple, &c. of NQ.

When a ray passes out of a vacuum into air, the sine of the angle of incidence is found to be to that of refraction as 100036 to 100000.

When it passes out of air into water, as about 4 to 3.

When out of air into glass, as about 17 to 11.

When out of air into a diamond, as about 5 to 2.

This relation of the sine of the angle of incidence to that of refraction, which is a proposition of the most extensive use in explaining the optical phenomena on physical or mechanical principles, may be demonstrated in the following easy and familiar manner.

Lemma I. The augmentations or diminutions of the squares of the velocities produced by the uniform action of accelerating or retarding forces, are proportional to the forces, and to the spaces along which they act, jointly, or are proportional to the products of the forces multiplied by the spaces.

Let two bodies be uniformly accelerated from a state of rest in the points A a, along the spaces AB, ab, fig. 5. by the accelerating forces Ff, and let AC, ac, be spaces described in equal times; it is evident, from what has been said under the articles GRAVITY and ACCELERATION, that because these spaces are described with motions uniformly accelerated, AC and ac are respectively the halves of the spaces which would be uniformly described during the same time with the velocities acquired at C and c, and are therefore

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Cause of
Refraction.Cause of
Refraction.

therefore measures of these velocities. And as these velocities are uniformly acquired in equal times, they are measures of the accelerating forces. Therefore $AC:ac=F:f$. Also, from the nature of uniformly accelerated motion, the spaces are proportional to the squares of the acquired velocities. Therefore, (using the symbols $\sqrt^2 C$, $\sqrt^2 c$, &c. to express the squares of the velocities at C , &c.) we have

$$\sqrt^2 B:\sqrt^2 C=AB:AC$$

$$\sqrt^2 C:\sqrt^2 c=AC^2:ac^2$$

$$\sqrt^2 c:\sqrt^2 b=ac:ab$$

Therefore, by equality of compound ratios

$$\sqrt^2 B:\sqrt^2 b=AB \times AC:ab \times ac=AB \times F:ab \times f.$$

And in like manner $\sqrt^2 D:\sqrt^2 d=AD \times F:ad \times f$;

and $\sqrt^2 B-\sqrt^2 D:\sqrt^2 b-\sqrt^2 d=BD \times F:bd \times f$.

Q. E. D.

Corol. If the forces are as the spaces inversely, the augmentations or diminutions of the squares of the velocities are equal.

Remark. If DB , db , be taken extremely small, the products $BD \times F$ and $bd \times f$ may be called the momentary actions of the forces, or the momentary increments of the squares of the velocities. It is usually expressed, by the writers on the higher mechanics, by the symbol $f s$, or $f ds$, where f means the accelerating force, and s or ds means the indefinitely small space along which it is uniformly exerted. And the proposition is expressed by the fluxionary equation $f s = v \dot{v}$, because $v \dot{v}$ is half the increment of v^2 , as is well known.

Plate CCCLIV. Fig. 6. *Lemma 2.* (being the 39th proposition of the first book of Newton's Principia.) If a particle of matter, moving with any velocity along the line AC , be impelled by an accelerating or retarding force, acting in the same or in the opposite direction, and if the intensity of the force in the different points B, F, H, C , &c. be as the ordinates BD, FG , &c. to the line DGE , the areas $BFGD$, $BHKD$, &c. will be as the changes made on the square of the velocity at B , when the particle arrives at the points F, H , &c.

For let BC be divided into innumerable small portions, of which let FH be one, and let the force be supposed to act uniformly, or to be of invariable intensity during the motion along FH ; draw GI perpendicular to HK : It is evident that the rectangle $FHIG$ will be as the product of the accelerating force by the space along which it acts, and will therefore express the momentary increment of the square of the velocity. (Lemma 1.) The same may be said of every such rectangle. And if the number of the portions, such as FH , be increased, and their magnitude diminished without end, the rectangles will ultimately occupy the whole curvilinear area, and the force will be continually varying in its intensity. The curvilinear areas will therefore be as the finite changes made on the square of the velocity, and the proposition is demonstrated.

Corol. The whole change made on the square of the velocity, is equal to the square of that velocity which the accelerating force would communicate to the particle by impelling it along BC from a state of rest in B . For the area $BCED$ will still express the square of this velocity, and it equally expresses the change made on the square of any velocity wherewith

the particle may pass through the point B , and is independent on the magnitude of that velocity.

Remark. The figure is adapted to the case where the forces all conspire with the initial motion of the particle, or all oppose it, and the area expresses an augmentation or a diminution of the square of the initial velocity. But the reasoning would have been the same, although, in some parts of the line BC , the forces had conspired with the initial motion, and in other parts had opposed it. In such a case, the ordinates which express the intensity of the forces must lie on different sides of the abscissa BC , and that part of the area which lies on one side must be considered as negative with respect to the other, and be subtracted from it. Thus, if the forces are represented by the ordinates of the dotted curve line DHe , which crosses the abscissa in H , the figure will correspond to the motion of a particle, which, after moving uniformly along AB , is subjected to the action of a variable accelerating force during its motion along BH , and the square of its initial velocity is increased by the quantity BHD ; after which it is retarded during its motion along HC , and the square of its velocity in H is diminished by a quantity HCe . Therefore the square of the initial velocity is changed by a quantity $BHD-HCe$, or $HCe-BHD$.

This proposition is perhaps the most important in the whole science of mechanics, being the foundation of every application of mechanical theory to the explanation of natural phenomena. No traces of it are to be found in the writings of philosophers before the publication of Newton's Principia, although it is assumed by John Bernoulli and other detractors from Newton's greatness as an elementary truth, without any acknowledgment of their obligations to its author. It is usually expressed by the equation $f s = v \dot{v}$ and $\int f s = v^2$, i.e. the sum of the momentary actions is equal to the whole or finite increment of the square of the velocity.

PROPOSITION.

When light passes obliquely into or out of a transparent substance, it is refracted so that the sine of the angle of incidence is to the sine of the angle of refraction in the constant ratio of the velocity of the refracted light to that of the incident light.

Let ST , KR (fig. 7.), represent two planes (parallel to, and equidistant from, the refracting surface XY) which bound the space in which the light, during its passage, is acted on by the refracting forces, as explained in n° 125. The intensity of the refracting forces being supposed equal at equal distances from the bounding planes, though any how different at different distances from them, may be represented by the ordinates Ta , nq , pr , cR , &c. of the curve $abnp c$, of which the form must be determined from observation, and may remain for ever unknown. The phenomena of inflected light show us that it is attracted by the refracting substance at some distances, and repelled at others.

Let the light, moving uniformly in the direction AB , enter the refracting stratum at B . It will not proceed in that direction, but its path will be incurvated upwards, while acted on by a repulsive force,

N n

and

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and downwards, while impelled by an attractive force. It will describe some curvilinear path Bdo CDE, which AB touches in B, and will finally emerge from the refracting stratum at E, and move uniformly in a straight line EF, which touches the curve in E. If, through b , the intersection of the curve of forces with its abscissa, we draw bo , cutting the path of the light in o , it is evident that this path will be concave upwards between B and o , and concave downwards between o and E. Also, if the initial velocity of the light has been sufficiently small, its path may be so much bent upwards, that in some point d its direction may be parallel to the bounding planes. In this case it is evident, that being under the influence of a repulsive force, it will be more bent upwards, and it will describe df , equal and similar to dB , and emerge in an angle gfs equal to ABG . In this case it is reflected, making the angle of reflection equal to that of incidence. By which it appears how reflection, refraction, and inflection, are produced by the same forces and performed by the same laws.

But let the velocity be supposed sufficiently great to enable the light to penetrate through the refracting stratum, and emerge from it in the direction EF; let AB and EF be supposed to be described in equal times: They will be proportional to the initial and final velocities of the light. Now, because the refracting forces *must* act in a direction perpendicular to the refracting surface (since they arise from the joint action of all the particles of a homogeneous substance which are within the sphere of mutual action), they cannot affect the motion of the light estimated in the direction of the refracting surface. If, therefore, AG be drawn perpendicular to ST, and FK to KR, the lines GB, EK, must be equal, because they are the motions AB, EF, estimated in the direction of the planes. Draw now EL parallel to AB. It is also equal to it. Therefore EL, EF, are as the initial and final velocities of the light. But EF is to EL as the sine of the angle ELK to the sine of the angle EFK; that is, as the sine of the angle ABH to the sine of the angle FEI; that is, as the sine of the angle of incidence to the sine of the angle of refraction.

By the same reasoning it will appear that light, moving in the direction and with the velocity FE, will describe the path EDB, and will emerge in the direction and with the velocity BA.

Let another ray enter the refracting stratum perpendicularly at B, and emerge at Q. Take two points N, P, in the line BQ, extremely near to each other, so that the refracting forces may be supposed to act uniformly along the space NP: draw NC, PD, parallel to ST, CM perpendicular to DP, and MO perpendicular to CD, which may be taken for a straight line. Then, because the forces at C and N are equal, by supposition they may be represented by the equal lines CM and NP. The force NP is wholly employed in accelerating the light along NP; but the force CM being transverse to the motion BD, is but partly so employed, and may be conceived as arising from the joint action of the forces CO, OM, of which CO only is employed in accelerating the motion of the light, while OM is employed in incurvating its path. Now it is evident, from the similarity of the triangles DCM, MCO, that $DC : CM$

$= CM : CO$, and that $DC \times CO = CM \times CM = NP \times NP$. But $DC \times CO$ and $NP \times NP$ are as the products of the spaces by the accelerating forces, and express the momentary increments of the squares of the velocities at C and N. (Lemma 1.) These increments, therefore, are equal. And as this must be said of every portion of the paths BCE and BNQ, it follows that the whole increment of the square of the initial velocity produced in the motion along BCE, is equal to the increment produced in the motion along BNQ. And, because the initial velocities were equal in both paths, their squares were equal. Therefore the squares of the final velocities are also equal in both paths, and the final velocities themselves are equal. The initial and final velocities are therefore in a constant ratio, whatever are the directions; and the ratio of the sines of the angles of incidence and refraction being the ratio of the velocities of the refracted and incident light, by the former case of prop. 1. is also constant.

Remark. The augmentation of the square of the initial velocity is equal to the square of the velocity which a particle of light would have acquired, if impelled from a state of rest at B along the line BQ, (Corol. of the Lemma 2.), and is therefore independent on the initial velocity. As this augmentation is expressed by the curvilinear area $aTbnpcR$, it depends both on the intensity of the refracting forces, expressed by the ordinates, and on the space through which they act, viz. TR. These circumstances arise from the nature of the transparent substance, and are characteristic of that substance. Therefore, to abbreviate language, we shall call this the *specific velocity*.

This specific velocity is easily determined for any substance in which the refraction is observed, by drawing Li perpendicular to EL, meeting in i the circle described with the radius EF. For Ei being equal to EF, will represent the velocity of the refracted light, and EL represent the velocity of the incident light, and $Ei^2 = EL^2 + Li^2$, and therefore Li^2 is the augmentation of the square of the initial velocity, and Li is the specific velocity.

It will now be proper to deduce some corollaries from these propositions, tending to explain the chief phenomena of refraction.

1. When light is refracted towards the perpendicular to the refracting surface, it is accelerated; and it is retarded when it is refracted from the perpendicular. In the first case, therefore, it must be considered as having been acted on by forces conspiring (in part at least) with its motion, and *vice versa*. Therefore, because we see that it is always refracted towards the perpendicular, when passing from a void into any transparent substance, we must conclude that it is, on the whole, attracted by that substance. We must draw the same conclusion from observing, that it is refracted from the perpendicular in its passage out of any transparent substance whatever into a void. It has been attracted backwards by that substance.

This acceleration of light in refraction is contrary to the opinion of those philosophers who maintain, that illumination is produced by the undulation of an elastic medium. Euler attempts to prove, by mechanical laws, that the velocities of the incident and refracted light are proportional to the sines of incidence and refraction, while our principles make them in this

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ratio inversely. Boscovich proposed a fine experiment for deciding this question. The aberration of the fixed stars arises from the combination of the motion of light with the motion of the telescope by which it is observed. Therefore this aberration should be greater or less when observed by means of a telescope filled with water, according as light moves slower or swifter through water than through air. He was mistaken in the manner in which the conclusion should be drawn from the observation made in the form prescribed by him: and the experiment has not yet been made in a convincing manner; because no fluid has been found of sufficient transparency to admit of the necessary magnifying power. It is an experiment of the greatest importance to optical science.

obliquity should prevent it from passing from the glass into a void. The finest experiment for illustrating the fact is, to take two pieces of mirror-glass, not silvered, and put them together with a piece of paper between them, forming a narrow margin all round to keep them apart. Plunge this apparatus into water. When it is held nearly parallel to the surface of the water, every thing at the bottom of the vessel will be seen clearly through the glasses; but when they are turned so as to be inclined about 50 degrees, they will intercept the light as much as if they were plates of iron. It will be proper to soak the paper in varnish, to prevent water from getting between the glasses.

What is called the brilliant cut in diamonds, is such a disposition of the posterior facets of the diamond, that the light is made to fall upon them so obliquely that none of it can go through, but all is reflected. To produce this effect in the greatest possible degree, is a matter of calculation, and merits the attention of the lapidary. When diamonds are too thin to admit of this form, they are cut in what is called the rose-fashion. This has a plain back, and the facets are all on the front, and so disposed as to refract the rays into sufficient obliquities, to be strongly reflected from the posterior plane. Doublets are made by cutting one thin diamond rose-fashion, and another similar one is put behind it, with their plane surfaces joined. Or, more frequently, the outside diamond has the anterior facets of the brilliant, and the inner has the form of the inner part of a brilliant. If they be joined with very pure and strongly refracting varnish, little light is reflected from the separating plane, and their brilliancy is very considerable, though still inferior to a true and deep brilliant. If no varnish be used, much of the light is reflected from the flat side, and the effect of the posterior facets is much diminished. But doublets might be constructed, by making the touching surfaces of a spherical form (of which the curvature should have a due proportion to the size of the stone), that would produce an effect nearly equal to that of the most perfect brilliant.

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The brilliant cut in diamonds produces total reflection.

3. Since the change made on the square of the velocity of the incident light is a constant quantity, it follows, that the refraction will diminish as the velocity of the incident light increases. For if L in fig. 7. be a constant quantity, and EL be increased, it is evident that the ratio of E , or its equal EF , to EL will be diminished, and the angle LEF , which constitutes the refraction, will be diminished. The physical cause of this is easily seen: When the velocity of the incident light is increased, it employs less time in passing through the refracting stratum or space between the planes ST and KR , and is therefore less influenced by the refracting forces. A similar effect would follow if the transparent body were moving with great velocity towards the luminous body.

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Refraction diminishes as the incident velocity increases.

Some naturalists have accounted for the different refrangibility of the differently coloured rays, by supposing that the red rays move with the greatest rapidity, and they have determined the difference of original velocity which would produce the observed difference of refraction. But this difference would be observed in the eclipses of Jupiter's satellites. They should be ruddy at their emersions, and be some seconds before they attain their pure whiteness; and they

N n 2

Plate CCCLIV.

2. If the light be moving within the transparent substance, and if its velocity (estimated in a direction perpendicular to the surface) do not exceed the specific velocity of that substance, it will not emerge from it, but will be reflected backwards in an angle equal to that of its incidence. For it must be observed, that in the figure of last proposition, the excess of the square of EF above the square of EL , is the same with the excess of the square of KF above the square of KL . Therefore the square of the specific velocity is equal to the augmentation or diminution of the square of the perpendicular velocity. If therefore the initial perpendicular velocity FK (fig. 8.) be precisely equal to the specific velocity, the light will just reach the farther side of the attracting stratum, as at B , where its perpendicular velocity will be completely extinguished, and its motion will be in the direction BT . But it is here under the influence of forces tending towards the plane KR , and its motion will therefore be still incurvated towards it; and it will describe a curve BD equal and similar to EB , and finally emerge back from the refracting stratum into the transparent substance in an angle RDA equal to KEF .

If the direction of the light be still more oblique, so that its perpendicular velocity is less than the specific velocity, it will not reach the plane ST , but be reflected as soon as it has penetrated so far that the specific velocity of the part penetrated (estimated by the compounding part of the area of forces) is equal to its perpendicular velocity. Thus the ray fE will describe the path $EdDa$ penetrating to bd , so that the corresponding area of forces $abce$ is equal to the square of fk , its perpendicular velocity.

The extreme brilliancy of dew drops and of jewels had often excited the attention of philosophers, and it always appeared a difficulty how light was reflected at all from the posterior surface of transparent bodies. It afforded Sir Isaac Newton his strongest argument against the usual theory of reflection, viz. that it was produced by impact on solid elastic matter. He was the first who took notice of the total reflection in great obliquities; and very properly asked how it can be said that there is any impact in this case, or that the reflecting impact should cease at a particular obliquity?

It must be acknowledged that it is a very curious circumstance, that a body which is perfectly transparent should cease to be so at a certain obliquity; that a great obliquity should not hinder light from passing from a void into a piece of glass; but that the same

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Rays at a certain obliquity are wholly reflected by transparent substances.

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they should become bluish immediately before they vanish in immersions. This is not observed. Besides, the difference in refrangibility is much greater in flint-glass than in crown-glass, and this would require a proportionally greater difference in the original velocities. This explanation therefore must be given up.

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The refraction of a star greater in the evening than in the morning.

It should follow, that the refraction of a star which is in our meridian at six o'clock in the evening should be greater than that of a star which comes on the meridian at six in the morning; because we are moving away from the first, and approaching to the last. But the difference is but $\frac{1}{10000}$ of the whole, and cannot be observed with sufficient accuracy in any way yet practised. A form of observation has been proposed by Dr Blair professor of practical astronomy in the university of Edinburgh, which promises a very sensible difference of refraction. It is also to be expected, that a difference will be observed in the refraction of the light from the east and western ends of Saturn's ring. Its diameter is about 26 times that of the earth, and it revolves in 10h. 32'; so that the velocity of its edge is about $\frac{1}{10000}$ of the velocity of the sun's light. If therefore the light be reflected from it according to the laws of perfect elasticity, or in the manner here explained, that which comes to us from the western extremity will move more slowly than that which comes from the eastern extremity in the proportion of 2500 to 2501. And if Saturn can be seen distinctly after a refraction of 30° through a prism, the diameter of the ring will be increased one half in one position of the telescope, and will be as much diminished by turning the telescope half round its axis; and an intermediate position will exhibit the ring of a distorted shape. This experiment is one of the most interesting to optical science, as its result will be a severe touchstone of the theories which have been attempted for explaining the phenomena on mechanical principles.

If the tail of a comet be impelled by the rays of the sun, as is with great probability supposed by Euler and others, the light by which its extreme parts are seen by us must have its velocity greatly diminished, being reflected by particles which are moving away from the sun with immense rapidity. This may perhaps be discovered by its greater aberration and refrangibility.

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All light subject to the same laws.

As common day-light is nothing but the sun's light reflected from terrestrial bodies, it is reasonable to expect that it will suffer the same refraction. But nothing but observation could assure us that this would be the case with the light of the stars; and it is rather surprising that the velocity of their light is the same with that of the sun's light. It is a circumstance of connection between the solar system and the rest of the universe. It was as little to be looked for on the light of terrestrial luminaries. If light be conceived as small particles of matter emitted from bodies by the action of accelerating forces of any kind, the vast diversity which we observe in the constitution of sublunary bodies should make us expect differences in this particular. Yet it is found, that the light of a candle, of a glowworm, &c. suffers the same refraction, and consists of the same colours. This circumstance is adduced as an argument against the theory of emission. It is

thought more probable that this sameness of velocity is owing to the nature of the medium, which determines the frequency of its undulations and the velocity of their propagation.

4. When two transparent bodies are contiguous, the light in its passage out of the one into the other will be refracted towards or from the perpendicular, according as the refracting forces of the second are greater or less than those of the first, or rather according as the area expressing the square of the specific velocity is greater or less. And as the difference of these areas is a determined quantity, the difference between the velocity in the medium of incidence and the velocity in the medium of refraction, will also be a determined quantity. Therefore the sine of the angle of incidence will be in a constant ratio to the sine of the angle of refraction; and this ratio will be compounded of the ratio of the sine of incidence in the first medium to the sine of refraction in a void; and the ratio of the sine of incidence in a void to the sine of refraction in the second medium. If therefore a ray of light, moving through a void in any direction, shall pass through any number of media bounded by parallel planes, its direction in the last medium will be the same as if it had come into it from a void.

5. It also follows from these propositions, that if the obliquity of incidence on the posterior surface of a transparent body be such, that the light should be reflected back again, the placing a mass of the same or of another medium in contact with this surface, will cause it to be transmitted, and this the more completely, as the added medium is more dense or more refractive; and the reflection from the separating surface will be the more vivid in proportion as the posterior substance is less dense or of a smaller refractive power. It is not even necessary that the other body be in contact; it is enough if it be so near that those parts of the refracting strata which are beyond the bodies interfere with or coincide with each other.

All these consequences are agreeable to experience. The brilliant reflection from a dew-drop ceases when it touches the leaf on which it rests: The brilliancy of a diamond is greatly damaged by moisture getting behind it: The opacity of the combined mirror plates, mentioned in the second corollary, is removed by letting water get between them: A piece of glass is distinctly or clearly seen in air, more faintly when immersed in water, still more faintly amidst oil of olives, and it is hardly perceived in spirits of turpentine. These phenomena are incompatible with the notion that reflection is occasioned by impact on solid matter, whether of the transparent body, or of any æther or other fancied fluid behind it; and their perfect coincidence with the legitimate consequences of the assumed principles, is a strong argument in favour of the truth of those principles.

It is worth while to mention here a fact taken notice of by Mr Beguelin, and proposed as a great difficulty in the Newtonian theory of refraction. In order to get the greatest possible refraction, and the simplest measure of the refracting power at the anterior surface of any transparent substance, Sir Isaac Newton enjoins us to employ a ray of light falling on the surface *quam obliquissime*. But Mr Beguelin found, that when the obliquity of incidence in glass was about

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Law of refraction when light passes out of one transparent body into another contiguous to it.

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An objection to the Newtonian theory of refraction.

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89° 50', no light was refracted, but that it was wholly reflected. He also observed, that when he gradually increased the obliquity of incidence on the posterior surface of the glass, the light which emerged last of all did not skim along the surface, making an angle of 90° with the perpendicular, as it should do by the Newtonian theory, but made an angle of more than ten minutes with the posterior surface. Also, when he began with very great obliquities, so that all the light was reflected back into the glass, and gradually diminished the obliquity of incidence, the first ray of light which emerged did not skim along the surface, but was raised about 10 or 15 minutes.

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Shown to
be the ne-
cessary con-
sequence
of that
theory, and
of course a
confirmation
of it.

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But all these phenomena are necessary consequences of our principles, combined with what observation teaches us concerning the forces which bodies exert on the rays of light. It is evident, from the experiments of Grimaldi and Newton, that light is both attracted and repelled by solid bodies. Newton's sagacious analysis of these experiments discovered several alternations of actual inflection and deflection; and he gives us the precise distance from the body when some of these attractions end and repulsion commences; and the most remote action to be observed in his experiments is repulsion. Let us suppose this to be the case, although it be not absolutely necessary. Let us suppose that the forces are represented by the ordinates of a curve $abnp$ (see fig. 7.) which crosses the abscissa in b . Draw bo parallel to the refracting surface. When the obliquity of incidence of the ray AB has become so great, that its path in the glass, or in the refracting stratum, does not cut, but only touches the line ob , it can penetrate no further, but is totally reflected; and this must happen in all greater obliquities. On the other hand, when the ray LE , moving within the glass, has but a very small perpendicular velocity, it will penetrate the refracting stratum no further than till this perpendicular velocity is extinguished, and its path becomes parallel to the surface, and it will be reflected back. As the perpendicular velocity increases by diminishing the obliquity of incidence, it will penetrate farther; and the last reflection will happen when it penetrates so far that its path touches the line ob . Now diminish the obliquity by a single second; the light will get over the line ob , will describe an arch $o dB$ concave upwards, and will emerge in a direction BA , which does not skim the surface, but is sensibly raised above it. And thus the facts observed by M. Beguelin, instead of being an objection against this theory, afford an argument in its favour.

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Euler's
theory of
undulation
contrary to
fact;

7. Those philosophers who maintain the theory of undulation, are under the necessity of connecting the dispersive powers of bodies with their mean refractive powers. Mr Euler has attempted to deduce a necessary difference in the velocity of the rays of different colours from the different frequency of the undulations, which he assigns as the cause of their different colorific powers. His reasoning on this subject is of the most delicate nature, and unintelligible to such as are not completely master of the infinitesimal calculus of partial differences, and is unsatisfactory to such as are able to go through its intricacies. It is contradicted by fact. He says, and indeed to be consistent he must say it, that musical sounds which differ great-

ly in acuteness are propagated through the air with different velocities: but one of the smallest bells in the chimes of St Giles's church in Edinburgh was struck against the rim of the very deep-toned bell on which the hours are struck. When the sound was listened to by a nice observer at the distance of more than two miles, no interval whatever could be observed. A similar experiment was exhibited to Mr Euler himself, by means of a curious musical instrument (if it can be so called) used at St Petersburg, and which may be heard at three or four miles distance. But the experiment with the bells is unexceptionable, as the two sounds were produced in the very same instant. This connection between the refrangibility in general and the velocity must be admitted, in its full extent, in every attempt to explain refraction by undulation; and Euler was forced by it to adopt a certain consequence which made a necessary connection between the mean refraction and the dispersion of heterogeneous rays. Confident of his analysis, he gave a deaf ear to all that was told him of Mr Dollond's improvements on telescopes, and asserted, that they could not be such as were related; for an increase of mean refraction must always be accompanied with a *determined* increase of dispersion. Newton had said the same thing, being misled by a limited view of his own principles; but the dispersion assigned by him was different from that assigned by Euler. The dispute between Euler and Dollond was confined to the decision of this question only; and when some glasses made by a German chemist at St Petersburg convinced Euler that his determination was erroneous, he had not the candour to give up the principle which had forced him to this determination of the dispersion, but immediately introduced a new theory of the achromatic telescopes of Dollond; a theory which took the artists out of the track marked out by mathematicians, and in which they had made considerable advances, and led them into another path, proposing *maxims* of construction hitherto untried, and inconsistent with real improvements which they had already made. The leading principle in this theory is to arrange the different ultimate images of a point which arise either from the errors of a spherical figure or different refrangibility, in a straight line passing through the centre of the eye. The theory itself is specious; and it requires great mathematical skill to accomplish this point, and hardly less to decide on the propriety of the construction which it recommends. It is therefore but little known. But that it is a false theory, is evident from one simple consideration. In the most indistinct vision arising from the worst construction, this rectilinear arrangement of the images obtains completely in that pencil which is situated in the axis, and yet the vision is indistinct. But, what is to our present purpose, this new theory is purely mathematical, suiting any observed dispersive power, and has no connection with the physical theory of undulations, or indeed with any mechanical principles whatever. But, by admitting any dispersive power, whatever may be the mean refraction, all the physical doctrines in his *Nova Theoria Lucis et Colorum* are overlooked, and therefore never once mentioned, although the effects of Mr Zeiher's glass are taken notice of as inconsistent with that mechanical propo-

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leads artists.

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proposition of Newton's which occasioned the whole dispute between Euler and Dollond.

They are indeed inconsistent with the universality of that proposition. Newton advances it in his optics merely as a mathematical proposition highly probable, but says that it will be corrected if *he shall find it false*. The ground on which he *seems* (for he does not expressly say so) to rest its probability is a limited view of his own principle, the action of bodies on light. He (not knowing any cause to the contrary) supposed that the action of all bodies was similar on the different kinds of light, that is, that the specific velocities of the differently coloured rays had a determined proportion to each other. This was gratuitous; and it might have been doubted by him who had observed the analogy between the chemical actions of bodies by elective attractions and repulsions, and the similar actions on light. Not only have different menstrua unequal actions on their solids, but the order of their affinities is also different. In like manner, we might expect not only that some bodies would attract light in general more than others, but also might differ in the proportion of their actions on the different kinds of light, and this so much, that some might even attract the red more than the violet. The late discoveries in chemistry show us some very distinct proofs, that light is not exempted from the laws of chemical action, and that it is susceptible of chemical combination. The changes produced by the sun's light on vegetable colours, shows the necessity of illumination to produce the green fecula; and the aromatic oils of plants, the irritability of their leaves by the action of light, the curious effects of it on the mineral acids, on manganese, and the calces of bismuth and lead, and the imbibition and subsequent emission of it by phosphorescent bodies, are strong proofs of its chemical affinities, and are quite inexplicable on the theory of undulations.

All these considerations taken together, had they been known to Sir Isaac Newton, would have made him expect differences quite anomalous in the dispersive powers of different transparent bodies; at the same time that they would have afforded to his sagacious mind the strongest arguments for the actual emission of light from the luminous body.

HAVING in this manner established the observed law of refraction on mechanical principles, showing it to be a necessary consequence of the known action of bodies on light, we proceed to trace its mathematical consequences through the various cases in which it may be exhibited to our observation. These constitute that part of the mathematical branch of optical science which is called *dioptrics*.

We are quite unacquainted with the law of action of bodies on light, that is, with the variation of the intensity of the attractions and repulsions exerted at different distances. All that we can say is, that from the experiments and observations of Grimaldi, Newton, and others, light is deflected towards a body or is attracted by it, at some distances, and repelled at others, and this with a variable intensity. The action may be extremely different, both in extent and force, in different bodies, and change by a very different law with the same change of distance. But,

amidst all this variety, there is a certain similarity arising from the joint action of many particles, which should be noticed, because it tends both to explain the similarity observed in the refractions of light, and also its connection with the phenomena of reflection.

The law of variation in the joint action of many particles adjoining to the surface of a refracting medium, is extremely different from that of a single particle; but when this last is known, the other may be found out. We shall illustrate this matter by a very simple case. Let DE (fig. 9.) be the surface of a medium, and let us suppose that the action of a particle of the medium on a particle of light extends to the distance EA, and that it is proportional to the ordinates ED, Ff, Gg, Hh, &c. of the line AbCgfd; that is, that the action of the particle E of the medium on a particle of light in F, is to its action on a particle in H as Ff to Hh, and that it is attracted at F but repelled at H, as expressed by the situation of the ordinates with respect to the abscissa. In the line AE produced to B, make EB, E χ , E κ , E γ , E ν , &c. respectively equal to EA, EH, EC, EG, EF, &c.

It is evident that a particle of the medium at B will exert no action on the particle of light in E, and that the particles of the medium in $\chi \gamma \nu$ E, will exert on it actions proportional to Hh, Gg, Ff, ED. Therefore, supposing the matter of the medium continuous, the whole action exerted by the row of particles EB will be represented by the area AbCDE; and the action of the particles between B and ν will be represented by the area AbC ν F, and that of the particles between E and ν by the area F ν DE.

Now let the particle of light be in F, and take F ϕ =AE. It is no less evident that the particle of light in F will be acted on by the particles in E ϕ alone, and that it will be acted on in the same manner as a particle in E is acted on by the particles in ν B. Therefore the action of the whole row of particles EB on a particle in F will be represented by the area AbC ν F. And thus the action on a particle of light in any point of AE will be represented by the area which lies beyond it.

But let us suppose the particles of light to be within the medium, as at ϕ , and make ϕd =AE. It is again evident that it is acted on by the particles of the medium between ϕ and d with a force represented by the area AbCDE, and in the opposite direction by the particles in E ϕ with a force represented by the area F ϕ DE. This balances an equal quantity of action, and there remains an action expressed by the area AbC ν F. Therefore, if an equal and similar line to AbCDE be described on the abscissa EB, the action of the medium on a particle of light in ϕ will be represented by the area $\phi f h B$, lying beyond it.

If we now draw a line AKLMRNPB whose ordinates CK, FQ, γ R, &c. are as the areas of the other curve, estimated from A and B; these ordinates will represent the whole forces which are exerted by the particles in EB, on a particle of light moving from A to B. This curve will cut the axis in points L, N such, that the ordinates drawn through them intercept areas of the first curve, which are equal on each side of the axis; and in these points the particle of light sustains no action from the medium. These points are very

Cause of Refraction.

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The law of variation in the action of many particles different from that of one; but may be known if it be known.
Plate CCCLIV.

138
The variation of the intensity of attractions and repulsions unknown.

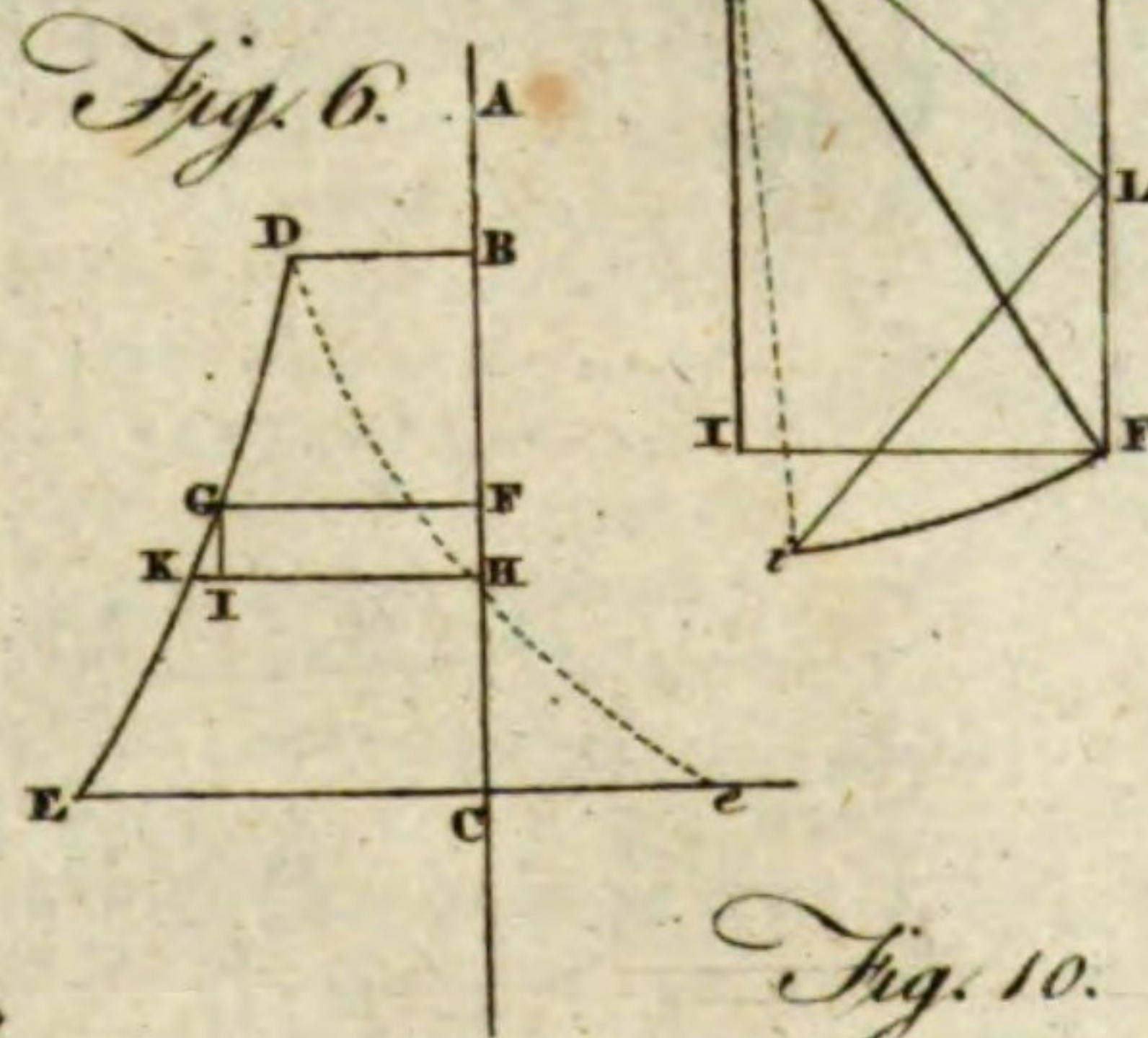
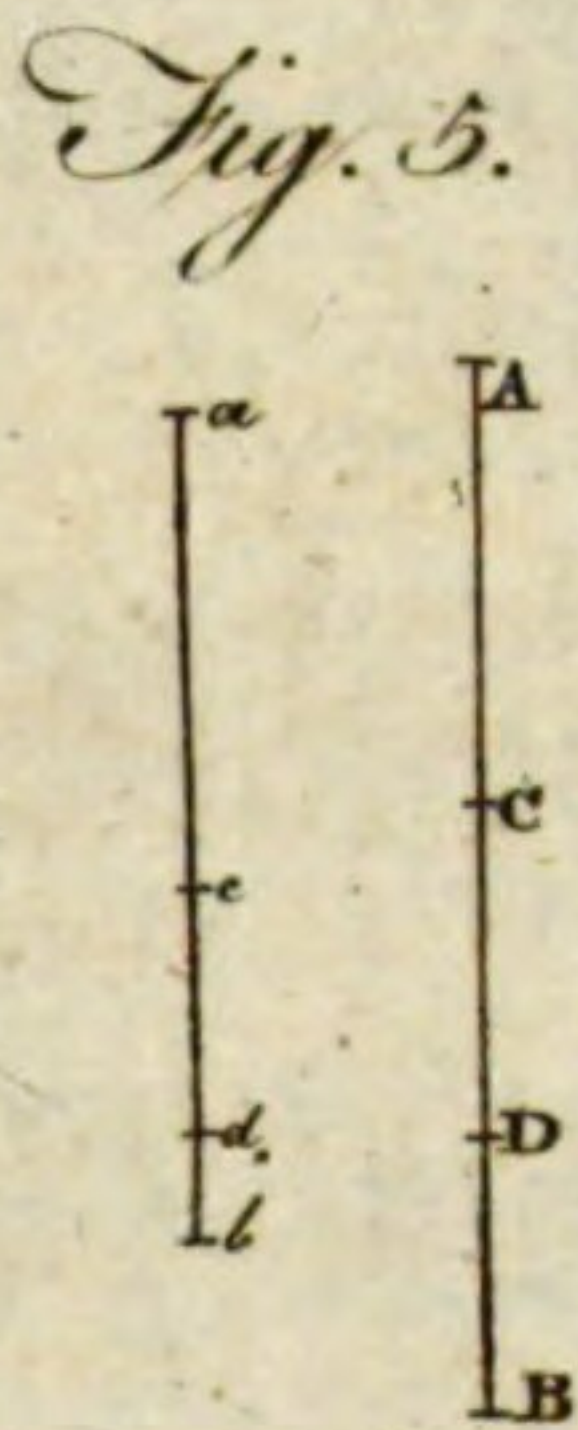
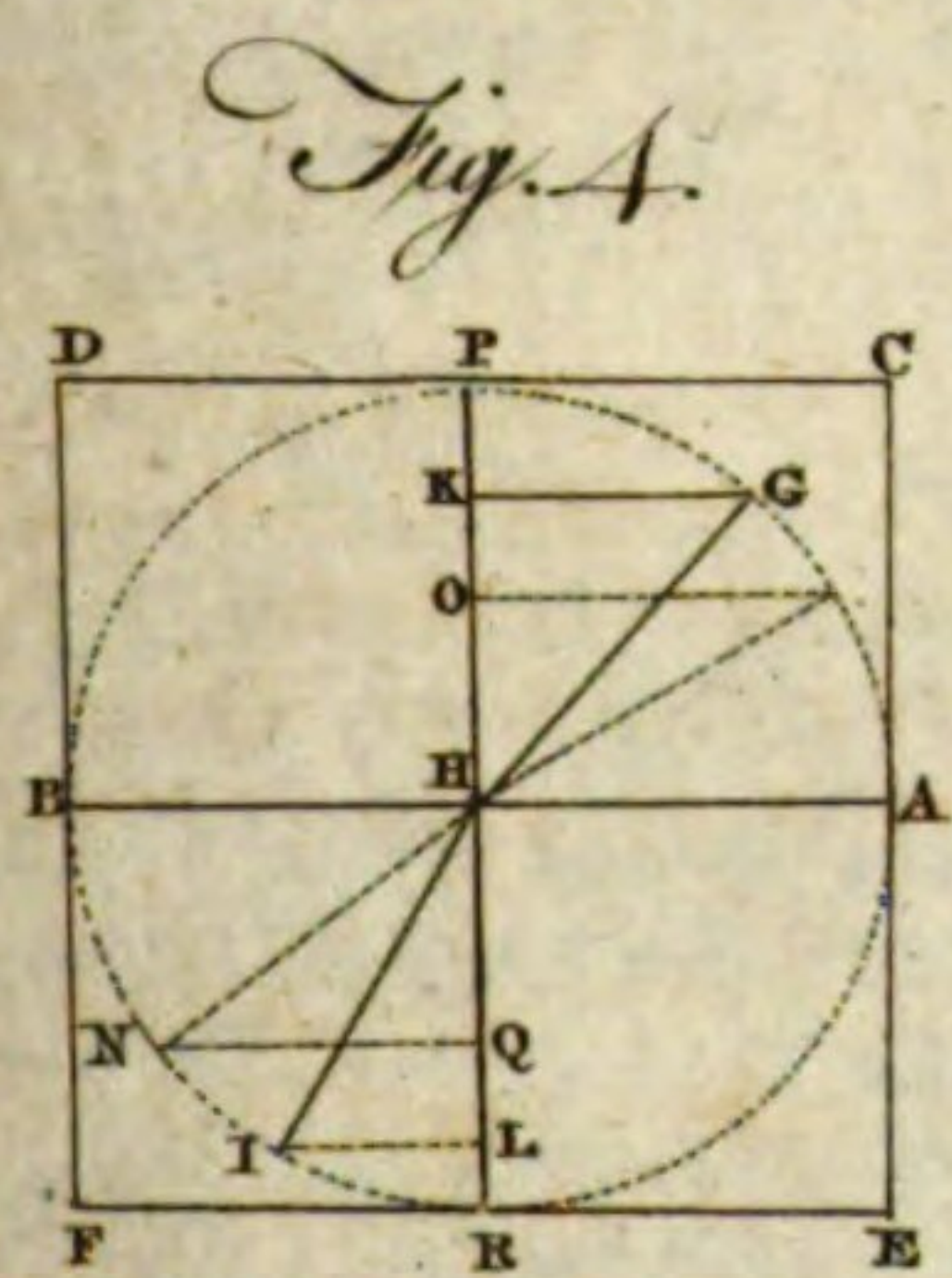
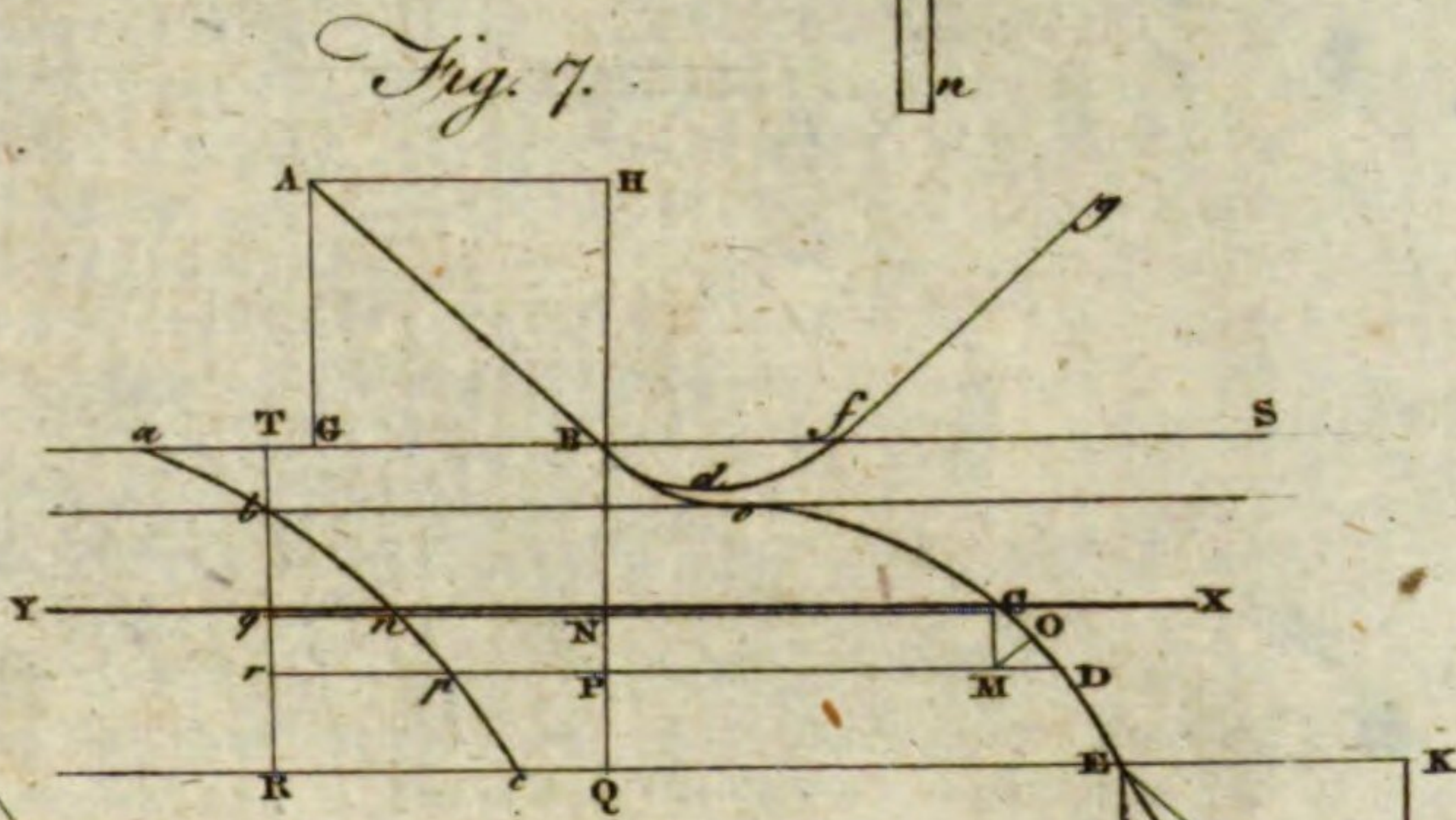
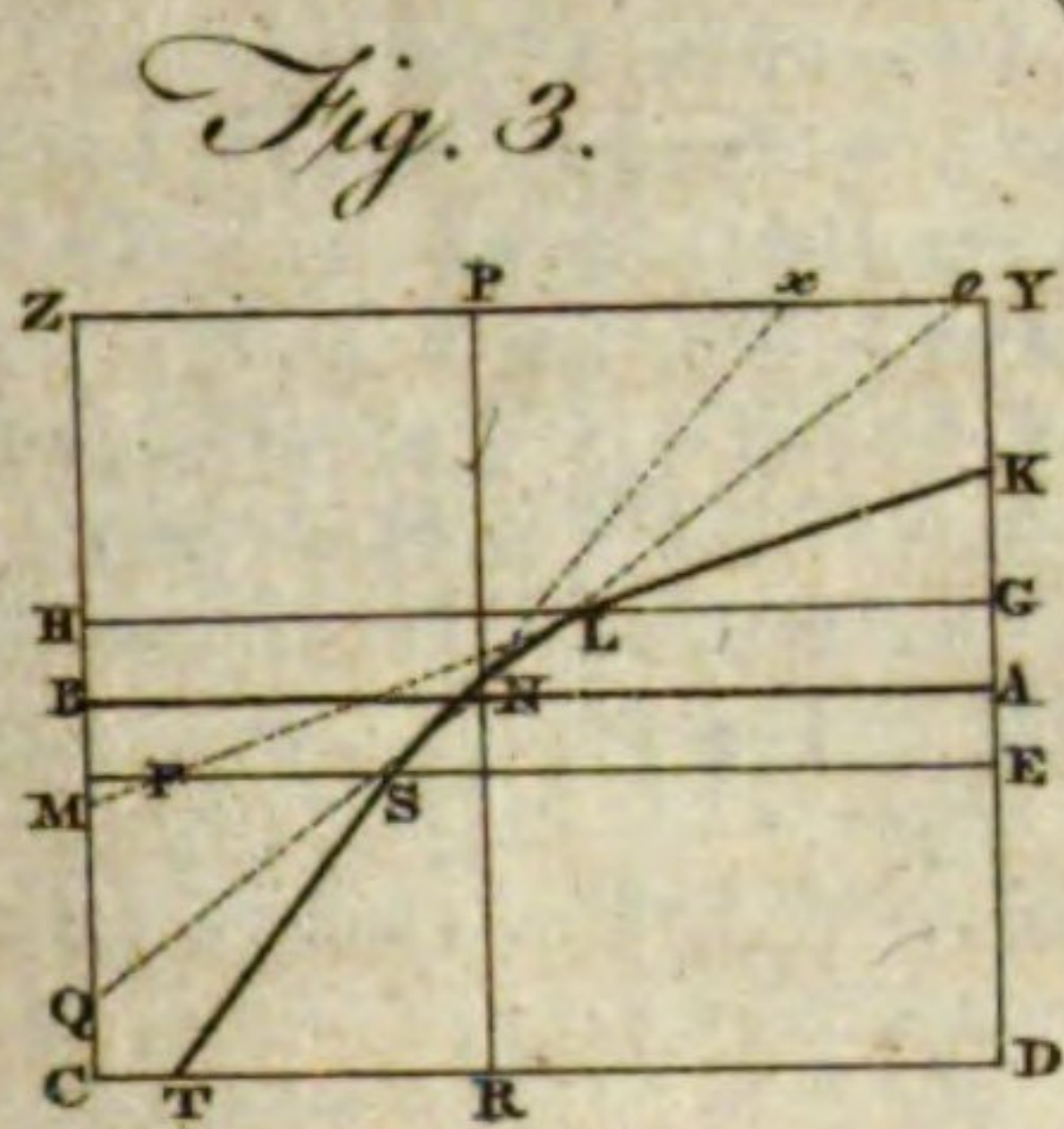
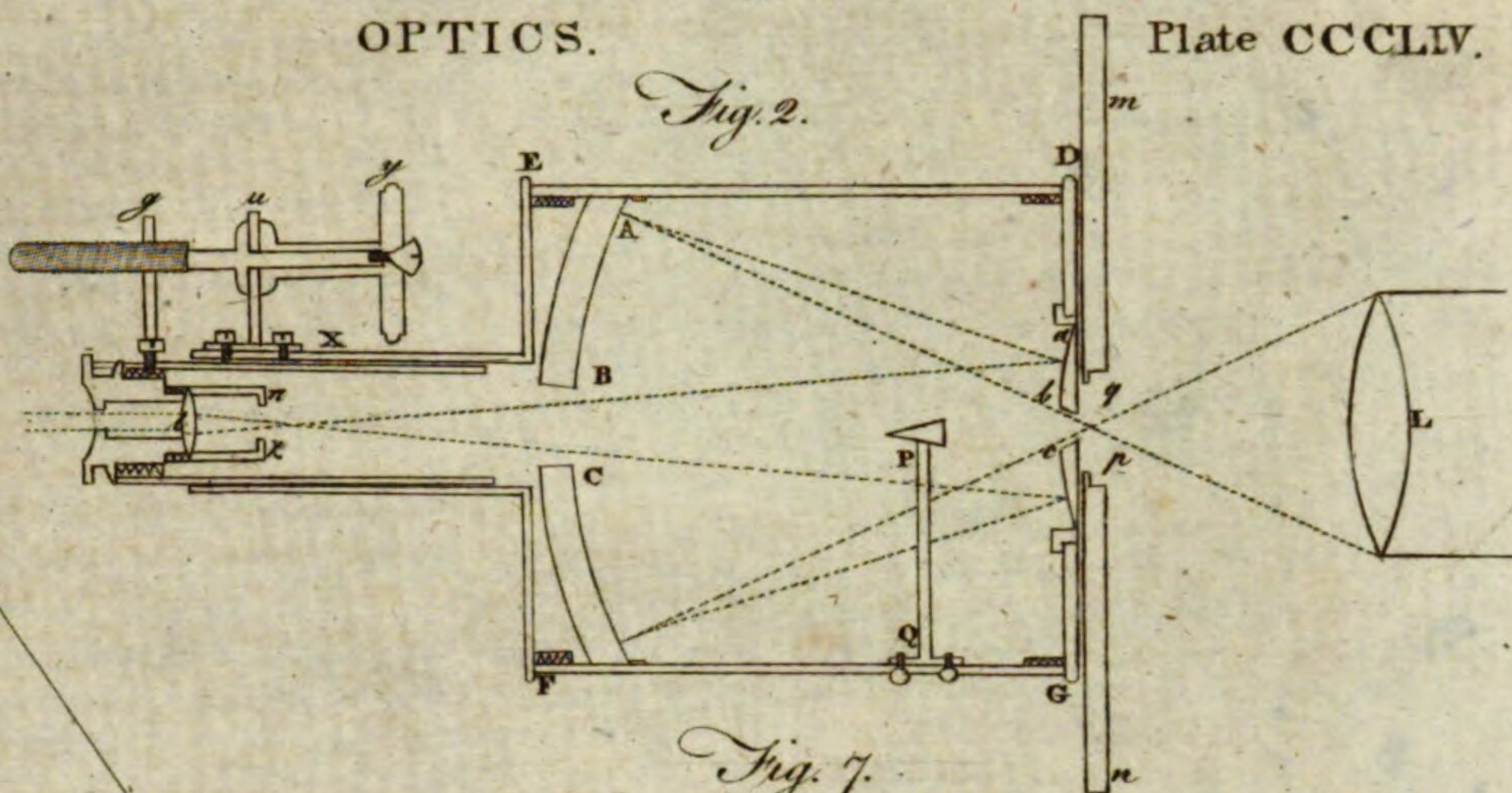
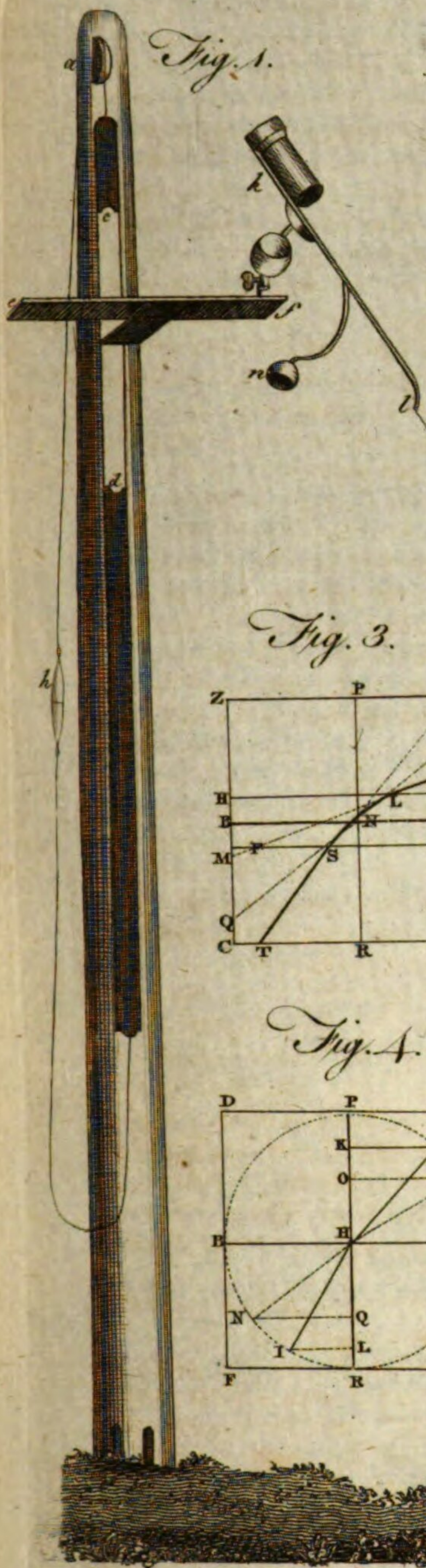
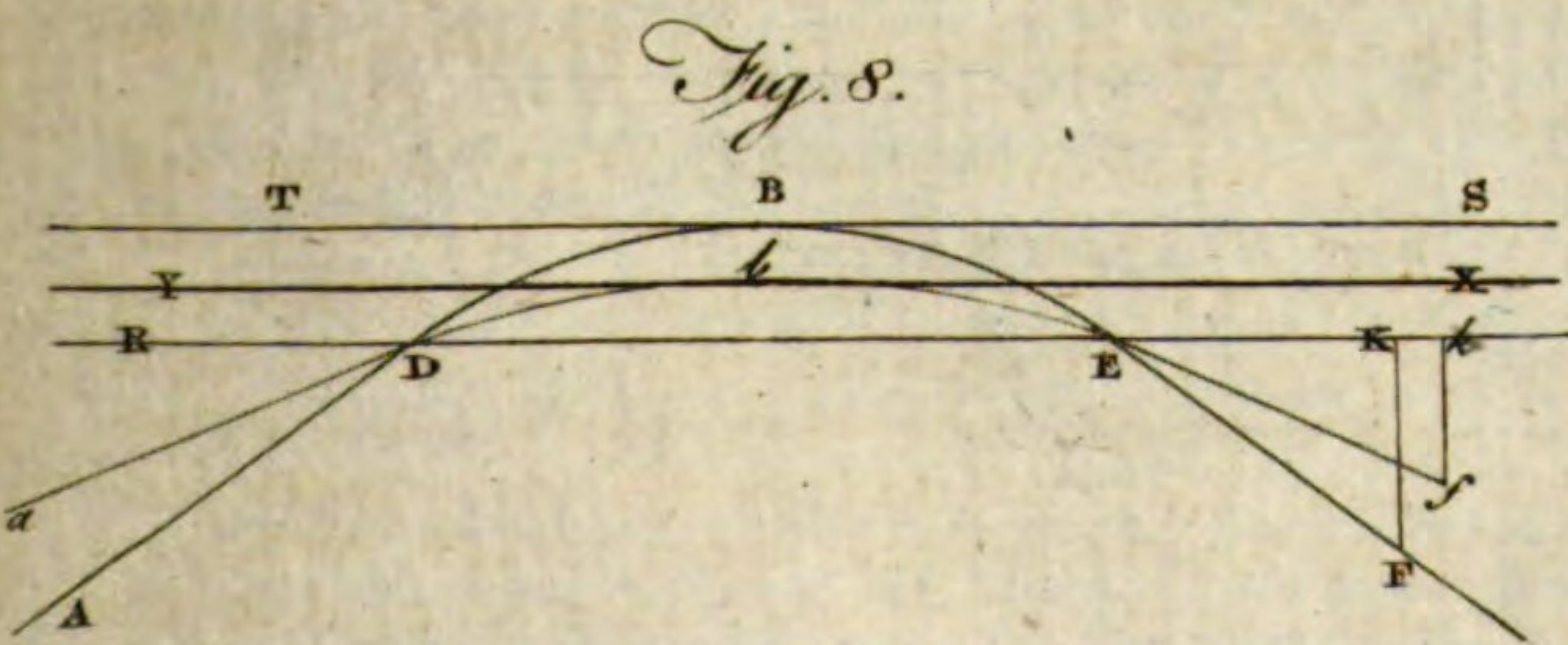
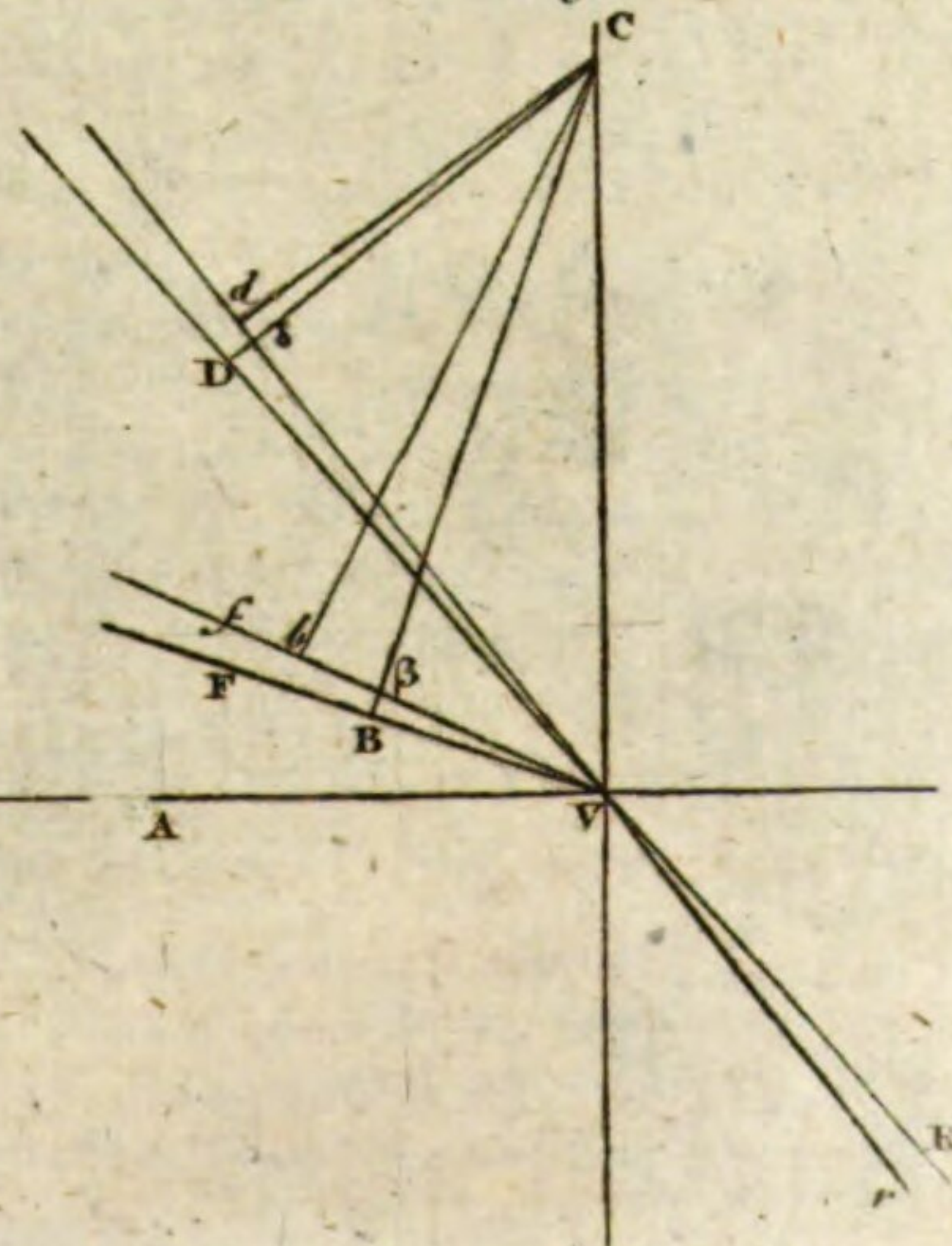


Fig. 10.



Cause of Refraction. very different from the similar points of the curve expressing the action of a single particle. These last are in the very places where the light sustains the greatest repulsive action of the whole row of particles. In the same manner may a curve be constructed, whose ordinates express the united action of the whole medium.

From these observations we learn in general, that a particle of light within the space of action is acted on with equal forces, and in the same direction, when at equal distances on each side of the surface of the medium.

Of the focal distance of rays refracted by passing out of one medium into another of different density and through a plane surface.

Lemma. The indefinitely small variation of the angle of incidence is to the simultaneous variation of the angle of refraction as the tangent of incidence is to the tangent of refraction; or, the cotemporaneous variations of the angles of incidence and refraction are proportional to the tangents of these angles.

Plate CCCLIV. 140 Let RVF, rVf (fig. 10.) be the progress of the rays refracted at V (the angle rVR being considered in its nascent or evanescent state), and VC perpendicular to the refracting surface VA. From C draw CD, CB perpendicular to the incident and refracted rays RV, VF, cutting rV, Vf in δ and β , and let Cd, Cb be perpendicular to rV, Vf.

Because the sines of incidence and refraction are in a constant ratio, their simultaneous variations are in the same constant ratio. Now the angle RVr is to the angle FVf in the ratio of $\frac{B\delta}{BV}$ to $\frac{D\beta}{DV}$; that is, of $\frac{BC}{BV}$ to $\frac{DC}{DV}$; that is, of $\frac{\sin. incid.}{\cos. incid.}$ to $\frac{\sin. refr.}{\cos. refr.}$; that is, of *tan. incid.* to *tan. refr.*

Corollary. The difference of these variations is to the greatest or least of them as the difference of the tangents to the greatest or least tangent.

PROBLEM.

Plate CCCLV. Let two rays RV, RP diverge from, or converge to, a point R (figs. 1, 2, 3, 4.), and pass through the plane surface PV separating two refracting mediums AB, of which let B be the most refracting, and let RV be perpendicular to the surface. It is required to determine the point of dispersion or convergence, F, of the refracted rays VD, PE.

Make VR to VG as the sine of refraction to the sine of incidence, and draw GIK parallel to the surface, cutting the incident ray in I. About the centre P, with the radius PI, describe an arch of a circle IF, cutting VR in F; draw PE tending from or towards F. We say PE is the refracted ray, and F the point of dispersion or convergence of the rays RV, RP, or the conjugate focus to R.

For since GI and PV are parallel and PF equal to

PI, we have $PF : PR = PI : PR = VG : VR = \sin. incid. : \sin. refr.$ But $PF : PR = \sin. PRV : \sin. PFV$, and RRV is equal to the angle of incidence at P; therefore PFV is the corresponding angle of refraction, FPE is the refracted ray, and F the conjugate focus to R.

Corol. 1. If diverging or converging rays fall on the surface of a more refracting medium, they will diverge or converge less after refraction, F being farther from the surface than R. The contrary must happen when the diverging or converging rays fall on the surface of a less refracting medium, because, in this case, F is nearer to the surface than R.

Corol. 2. Let Rp be another ray, more oblique than RP, the refracting point p being farther from V, and let fpe be the refracted ray, determined by the same construction. Because the arches FI, fi, are perpendicular to their radii, it is evident that they will converge to some point within the angle RIK, and therefore will not cross each other between F and I: therefore Rf will be greater than RF, as RF is greater than RG, for similar reasons. Hence it follows, that all the rays which tended from or towards R, and were incident on the whole of VPp, will not diverge from or converge to F, but will be diffused over the line GFf. This diffusion is called aberration from the focus, and is so much greater as the rays are more oblique. No rays flowing from or towards R will have point of concurrence with RV nearer to R than F is: But if the obliquity be inconsiderable, so that the ratio of RP to FP does not differ sensibly from that of RV to FV, the point of concurrence will not be sensibly removed from G. G is therefore usually called the *conjugate focus* to R. It is the conjugate focus of an indefinitely slender pencil of rays falling perpendicularly on the surface. The conjugate focus of an oblique pencil, or even of two oblique rays, whose dispersion on the surface is considerable, is of more difficult investigation. See *Gravesande's Natural Philosophy* for a very neat and elementary determination (E.)

In a work of this kind, it is enough to have pointed out, in an easy and familiar manner, the nature of optical aberration. But as this is the chief cause of the imperfection of optical instruments, and as the only method of removing this imperfection is to diminish this aberration, or correct it by a subsequent aberration in the opposite direction, we shall here give a fundamental and very simple proposition, which will (with obvious alterations) apply to all important cases. This is the determination of the focus of an infinitely slender pencil of oblique rays RP, Rp.

Retaining the former construction for the refracted ray FP, draw FS perpendicular to FP, cutting the perpendicular through P on the point S, and describe on PS a semicircle, cutting FP in ϕ ; we say that ϕ is the focus of an infinitely slender pencil diverging from or converging to R, with the obliquity VRP.

Suppose

(E) We refer to Gravesande, because we consider it as of importance to make such a work as ours serve as a general index to science and literature. At the same time we take the liberty to observe, that the focus in question is virtually determined by the construction which we have given: for the points P, F of the line PF are determined; and therefore its position is also determined. The same is true of the position of pf, and therefore the intersection of the two lines ϕ is likewise determined.

Refraction
by Spherical
Surfaces.

Suppose the ray Rp infinitely near to RP , and draw Rr perpendicular to RP , draw pr , pS , $p\phi$; it follows from the lemma, that if ϕ be the focus of refracted rays, the variation Pp of the angle of refraction is to the corresponding variation PRp of the angle of incidence as the tangent of the angle of refraction VFP to the tangent of the angle of incidence VRP . Now Pp may be considered as coinciding with the arch of the semicircles. Therefore the angles PRp , Prp are equal, as also the angles $P\phi p$, PSp . But PSp is to Prp as Pr to PS ; that is, as VR to VF ; that is, as the cotangent of the angle of incidence to the cotangent of the angle of refraction; that is, as the tangent of the angle of refraction to the tangent of the angle of incidence. Therefore the point ϕ is the focus.

Of Refraction by Spherical Surfaces.

General Problem.

To find the focus of refracted rays, the focus of incident rays being given.

Let PV (figs. 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,) be a spherical surface whose centre is C , and let the incident light diverge from or converge to R .

Solution. Draw the ray RC through the centre, cutting the surface in the point V , which we shall denominate the *vertex*, while RC is called the *axis*. This ray passes on without refraction, because it coincides with the perpendicular to the surface. Let RP be another incident ray, which is refracted at P , draw the radius PC . In RP make RE to RP as the sine of incidence m to the sine of refraction n ; and about the centre R , with the distance RE , describe the circle EK , cutting PC in K ; draw RK and PF parallel to it, cutting the axis in F . PF is the refracted ray, and F is the focus.

For the triangles PCF , KCR are similar, and the angles at P and K are equal. Also PK is equal to PE , and RPD is the angle of incidence. Now $m : n = PK : RP = \sin. DPR : \sin. RKP = \sin. DPR : \sin. CPF$. Therefore CPF is the angle of refraction corresponding to the angle of incidence RPD , and PF is the refracted ray and F the focus. Q. E. D.

Cor. 1. $CK : CP = CR : CF$, and $CF = \frac{CP \times CR}{CK}$

Now $CP \times CR$ is a constant quantity; and therefore CF is reciprocally as CK , which evidently varies with a variation of the arch VP . Hence it follows, that all the rays flowing from R are not collected at the conjugate focus F . The ultimate situation of the point F , as the point P gradually approaches to, and at last coincides with, V , is called the *conjugate focus of central rays*, and the distance between this focus and the focus of a lateral ray is called the *aberration* of that ray, arising from the spherical figure.

There are, however, two situations of the point R such, that all the rays which flow from it are made to diverge from one point. One of those is C (fig. 5.), because they all pass this without refraction, and therefore still diverge from C ; the other is when rays in the rare medium with a convex surface flow from a point R , so situated beyond the centre that CV is to CR as the sine of incidence in the rare medium is to the sine of refraction in the denser, or when rays in the rare medium fall on the convex surface of the den-

N^o 248.

ser, converging to F , so situated that $CF : CV = m : n$. In this case they will all be dispersed from F , so situated that $CV : CF = n : m = CR : CV$ for sine $RPC : \text{sine } RKC = n : m = CR : CP = \text{sine } RPC : \text{sine } PRC$. Therefore the angle PRC is equal to RKC , or to FPC (by construction of the problem), and the angle C is common to the triangles PRC , FPC ; they are therefore similar, and the angles PRC , FPC are equal, and $n : m = CP : CF = CK : CR = CR : CP$; therefore $CP : CK = CP^2 : CR^2$; but CP and CR are constant quantities, and therefore CK is a constant quantity, and (by the corollary) CF is a constant quantity, and all the rays flowing from R are dispersed from F by refraction. In like manner rays converging to F will by refraction converge to R . This was first observed by Huygens.

2. If the incident ray $R'P$ (fig. 5.) is parallel to the axis RC , we have PO to CO as the sine of incidence to the sine of refraction. For the triangles $R'PK'$, PCO are similar, and $PO : CO = R'K' : R'P = m : n$.

3. In this case, too, we have the focal distance of central parallel rays reckoned from the vertex $= \frac{m}{m-n} \times VC$. For since PO is ultimately VO , we have $m : n = VO : CO$, and $m-n : m = VO - CO : VO = VC : VO$, and $VO = \frac{m}{m-n} \times VC$. This is called the principal focal distance, or focal distance of parallel rays. Also CO , the principal focal distance reckoned from the centre, $= \frac{n}{m-n} \times VC$.

N. B. When m is less than n , $m-n$ is a negative quantity.—Also observe, that in applying symbols to this computation of the focal distances, those lines are to be accounted positive which lie from their beginnings, that is, from the vertex, or the centre, or the radiant point, in the direction of the incident rays. Thus when rays diverge from R on the convex surface of a medium, VR is accounted negative and VC positive. If the light passes out of air into glass, m is greater than n ; but if it passes out of glass into air, m is less than n . If, therefore, parallel rays fall on the convex surface of glass out of air, in which case $m : n = 3 : 2$ very nearly, we have for the principal focal distance $\frac{3}{3-2} VC$, or $+3VC$. But if it pass out of glass into the convex surface of air, we have $VO = \frac{2}{2-3} VC$, or $-2VC$; that is, the focus O will be in the same side of the surface with the incident light. In like manner, we shall have for these two cases $CO = +2VC$ and $-3VC$.

4. By construction we have $RK : RP = m : n$ by similarity of triangles $PF : RK = CF : CR$ therefore $PF : PR = mCF : nCR$ and $mPR \times CF = nCR \times PF$ therefore $mPR : nCR = PF : CF$ and $mPR - nCR : mPR = PF - CF : PF$ ultimately $mVR - nCR : mVR = VC : VF$

This is a very general optical theorem, and affords an easy method for computing the focal distance of refracted rays.

For this purpose let VR , the distance of the radiant point,

Refraction
by Spheri-
cal Surfa-
ces.

point, be expressed by the symbol r , the distance of the focus of refracted rays by the symbol f , and the radius of the spherical surface by a ; we have

$$mr - nr - a : mr = a : f, \text{ and } f = \frac{mar}{mr - nr - a} = \frac{mar}{m - nr + nd}$$

In its application due attention must be paid to the qualities of r and a , whether they be positive or negative, according to the conditions of last corollary.

Plate
CCCLV.

5. If Q (fig. 8.) be the focus of parallel rays coming from the opposite side, we shall have $RQ : QC = RV : VF$. For draw Cq parallel to PF , cutting RP in q ; then $Rq : qC = RP : PF$. Now q is the focus of the parallel rays FP , Cq . And when the point P ultimately coincides with the point V , q must coincide with Q , and we have $RQ : QC = RV : VF$.

This is the most general optical theorem, and is equally applicable to lenses, or even to a combination of them, as to simple surfaces. It is also applicable to reflections, with this difference, that Q is to be assumed the focus of parallel rays coming the same way with the incident rays. It affords us the most compendious methods of computing symbolically and arithmetically the focal distances in all cases.

6. We have also $Rq : RP = RV : RF$, and ultimately for central rays $RQ : RV = RV : RF$, and $RF = \frac{RV^2}{RQ}$.

7. Also $Rq : RC = RP : RF$, and ultimately $RQ : RV = RC : RF$, and $RF = \frac{RV \times RC}{RQ}$. *N. B.* These four points Q , V , C , F , either lie all one way from R , or two of them forward and two backward.

8. Also, making O the principal focus of rays coming the same way, we have $Rq : qC = Co : oF$, and ultimately $RQ : Qc = cO : OF$, and $OF = \frac{QC \times CO}{RQ}$, and therefore reciprocally proportional to RQ , because $QC \times co$ is a constant quantity.

These corollaries or theorems give us a variety of methods for finding the focus of refracted rays, or the other points related to them; and each formula contains four points, of which any three being given the fourth may be found. Perhaps the last is the most simple, as the quantity $oc \times cQ$ is always negative, because o and Q are on different sides.

9. From this construction we may also derive a very easy and expeditious method of drawing many refracted rays. Draw through the centre C (fig. 15. 16.) a line to the point of incidence P , and a line CA parallel to the incident ray RP . Take VO to VC as the sine of incidence to the sine of refraction, and about A , with the radius VO , describe an arch of a circle cutting PC produced in B . Join AB ; and PF parallel to AB is the refracted ray. When the incident light is parallel to RC , the point A coincides with V , and a circle described round V with the distance VO will cut the lines PC , pC , &c. in the points Bb . The demonstration is evident.

Having thus determined the focal distance of refracted rays, it will be proper to point out a little more particularly its relation to its conjugate focus of incident rays. We shall consider the four cases of

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light incident on the convex or concave surface of a denser or a rarer medium.

Refraction
by Spheri-
cal Surfa-
ces.

1. Let light moving in air fall on the convex surface of glass (fig. 5. to fig. 14.). Let us suppose it tending to a point beyond the glass infinitely distant. It will be collected to its principal focus a beyond the vertex V . Now let the incident light converge a little, so that R is at a great distance beyond the surface. The focus of refracted rays F will be a little within O or nearer to V . As the incident rays are made to converge more and more, the point R comes nearer to V , and the point F also approaches it, but with a much slower motion, being always situated between O and C till it is overtaken by R at the centre C , when the incident light is perpendicular to the surface in every point, and therefore suffers no refraction. As R has overtaken F at C , it now passes it, and is again overtaken by it at V . Now the point R is on the side from which the light comes, that is, the rays diverge from R . After refraction they will diverge from F a little without R ; and as R recedes farther from V , F recedes still farther, and with an accelerated motion, till, when R comes to Q , F has gone to an infinite distance, or the refracted rays are parallel. When R still recedes, F now appears on the other side, or beyond V ; and as R recedes back to an infinite distance, F has come to O : and this completes the series of variations, the motion of F during the whole changes of situation being in the same direction with the motion of R .

2. Let the light moving in air fall on the concave surface of glass; and let us begin with parallel incident rays, conceiving, as before, R to lie beyond the glass at an infinite distance. The refracted rays will move as if they came from the principal focus O , lying on that side of the glass from which the light comes. As the incident rays are made gradually more converging, and the point of convergence R comes toward the glass, the conjugate focus F moves backward from O ; the refracted rays growing less and less diverging, till the point R comes to Q , the principal focus on the other side. The refracted rays are now parallel, or F has retreated to an infinite distance. The incident light converging still more, or R coming between Q and V , F will appear on the other side, or beyond the surface, or within the glass, and will approach it with a retarded motion, and finally overtake R at the surface of the glass. Let R continue its motion backwards (for it has all the while been moving backwards, or in a direction contrary to that of the light); that is, let R now be a radiant point, moving backwards from the surface of the glass. F will at first be without it, but will be overtaken by it at the centre C , when the rays will suffer no refraction. R still receding, will get without F ; and while R recedes to an infinite distance, F will recede to O , and the series will be completed.

3. Let the light moving in glass fall on the convex surface of air; that is, let it come out of the concave surface of glass, and let the incident rays be parallel, or tending to R , infinitely distant: they will be dispersed by refraction from the principal focus O within the glass. As they are made more converging, R comes nearer, and F retreats backward, till R comes

O o

to

Of Glasses. to Q , the principal focus without the glass; when F is now at an infinite distance within the glass, and the refracted rays are parallel. R still coming nearer, F now appears before the glass, overtakes R at the centre C , and is again overtaken by it at V . R now becoming a radiant point within the glass, F follows it backwards, and arrives at O , when R has receded to an infinite distance, and the series is completed.

4. Let the incident light, moving in glass, fall on the concave surface of air, or come out of the convex surface of glass. Let it tend to a point R at an infinite distance without the glass. The refracted rays will converge to O , the principal focus without the glass. As the incident light is made more converging, R comes towards the glass, while F , setting out from v , also approaches the glass, and R overtakes it at the surface V . R now becomes a radiant point within the glass, receding backwards from the surface. F recedes slower at first, but overtakes R at the centre C , and passes it with an accelerated motion to an infinite distance; while R retreats to Q , the principal focus within the glass. R still retreating, F appears before the glass; and while R retreats to an infinite distance, F comes to V , and the series is completed.

§ 2. Of Glasses.

142 **Lenses,** **how many.** GLASS for optical purposes may be ground into nine different shapes. Glasses cut into five of those shapes are called *lenses*, which together with their axes are described in vol. 6. page 33. (See DIOPTRICS). The other four are,

- Plate CCCLVI.**
1. A *plane-glass*, which is flat on both sides, and of equal thickness in all its parts, as EF , fig. 1.
 2. A *flat plano-convex*, whose convex side is ground into several little flat surfaces, as A . fig. 2.
 3. A *prism*, which has three flat sides, and when viewed endwise appears like an equilateral triangle, as B .
 4. A *concavo-convex* glass, as C , which has hitherto received no name, and is seldom, if ever, made use of in optical instruments.

A ray of light Gh (fig. 1.) falling perpendicularly on a plane glass EF , will pass through the glass in the same direction hi , and go out of it into the air in the same straight line ih .

A ray of light AB falling obliquely on a plane glass, will go out of the glass in the same direction, but not in the same straight line: for in touching the glass, it will be refracted in the line BC ; and in leaving the glass, it will be refracted in the line CD .

Fig. 3. to 6. **Lemma.** There is a certain point E within every double convex or double concave lens, through which every ray that passes will have its incident and emergent parts QA , aq parallel to each other: but in a plano-convex or plano-concave lens, that point E is removed to the vertex of the concave or convex surface; and in a meniscus, and in that other concavo-convex lens, it is removed a little way out of them, and lies next to the surface which has the greatest curvature.

For let REr be the axis of the lens joining the centres R , r of its surfaces A , a . Draw any two of their semidiameters RA , ra parallel to each other, and join the points A , a , and the line Aa will cut the axis in the point E above described. For the triangles REA , raE being equiangular, RE will be to Er in the given

ratio of the semidiameters RA , ra ; and consequently the point E is invariable in the same lens. Now supposing a ray to pass both ways along the line Aa , it being equally inclined to the perpendiculars to the surfaces, will be equally bent, and contrarywise in going out of the lens; so that its emergent parts AQ , aq will be parallel. Now any of these lenses will become plano-convex or plano-concave, by conceiving one of the semidiameters RA , ra to become infinite, and consequently to become parallel to the axis of the lens, and then the other semidiameter will coincide with the axis; and so the points A , E or a , E will coincide. $Q. E. D.$

Corol. Hence when a pencil of rays falls almost perpendicularly upon any lens, whose thickness is inconsiderable, the course of the ray which passes through E , above described, may be taken for a straight line passing through the centre of the lens, without sensible error in sensible things. For it is manifest from the length of Aa and from the quantity of the refractions at its extremities, that the perpendicular distance of AQ , aq when produced, will be diminished both as the thickness of the lens and the obliquity of the ray is diminished.

PROPOSITION I.

To find the focus of parallel rays falling almost perpendicularly upon any given lens.

Let E be the centre of the lens, R and r the centres of its surfaces, Rr its axis, gEG a line parallel to the incident rays upon the surface B , whose centre is R . Parallel to gE draw a semidiameter BR , in which produced let V be the focus of the rays after their first refraction at the surface B , and joining Vr , let it cut gE produced in G , and G will be the focus of the rays that emerge from the lens. **Fig. 7. to 12.**

For since V is also the focus of the rays incident upon the second surface A , the emergent rays must have their focus in some point of that ray which passes straight through this surface; that is, in the line Vr , drawn through its centre r : and since the whole course of another ray is reckoned a straight line gEG *, its intersection G with Vr determines the focus of them all. $Q. E. D.$

Corol. 1. When the incident rays are parallel to the axis rR , the focal distance EF is equal to EG . For let the incident rays that were parallel to gE be gradually more inclined to the axis till they become parallel to it; and their first and second focuses V and G will describe circular arches VT and GF whose centres are R and E . For the line RV is invariable; being in proportion to RB in a given ratio of the lesser of the lines of incidence and refraction to their difference*; consequently the line EG is also invariable, being in proportion to the given line RV in the given ratio of rE to rR , because the triangles EGr , RVr are equiangular.

Corol. 2. The last proportion gives the following rule for finding the focal distance of any thin lens. As Rr , the interval between the centres of the surfaces, is to rE , the semidiameter of the second surface, so is RV or RT , the continuation of the first semidiameter to the first focus, to EG or EF , the focal distance of the lens; which, according as the lens is thicker or thinner in the middle than at its edges, must lie on the

Fig. 7. to 12.
143
The focus of parallel rays falling perpendicularly upon any lens.

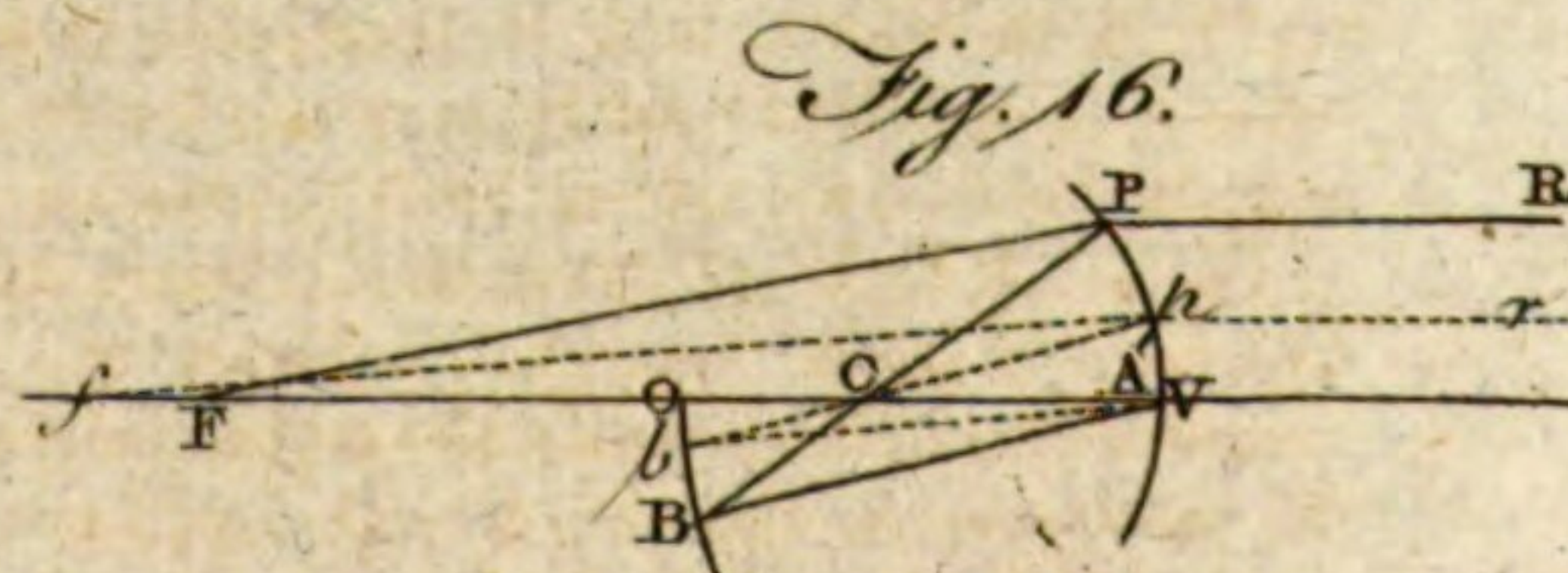
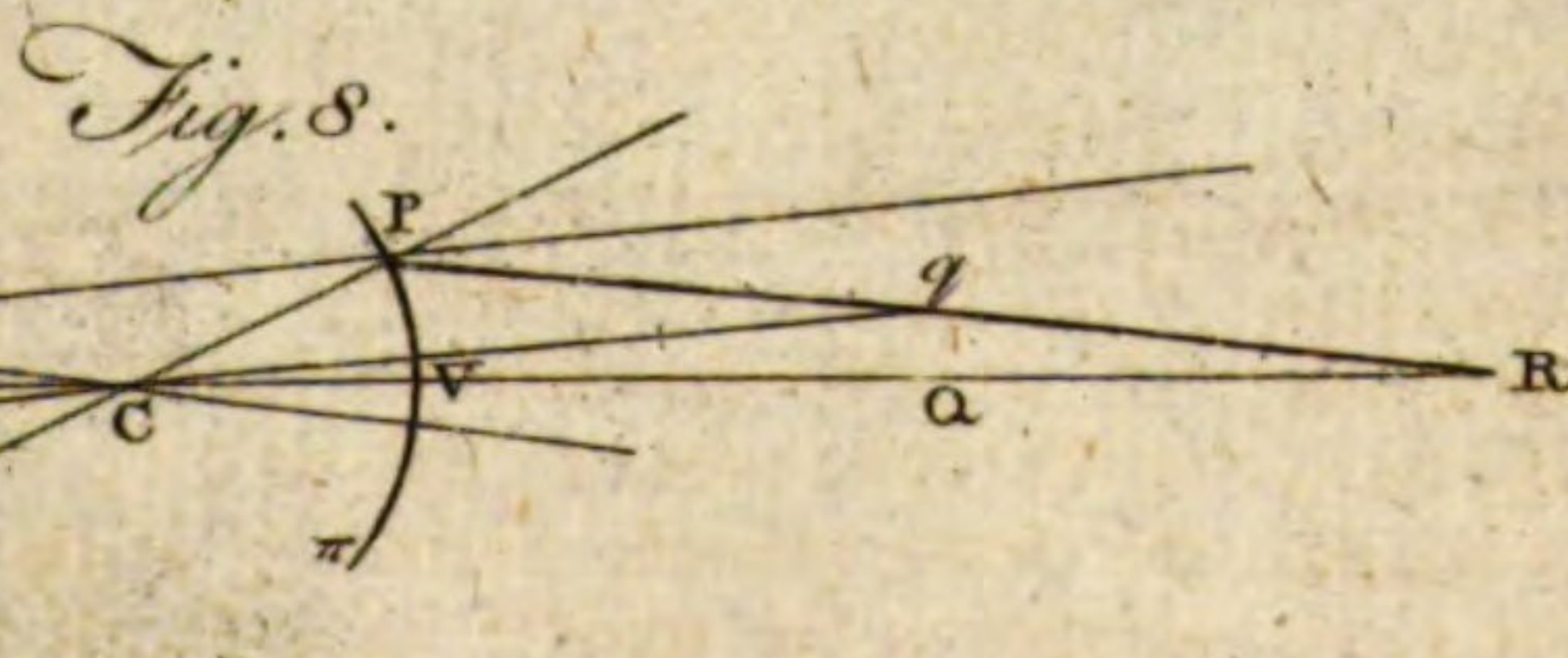
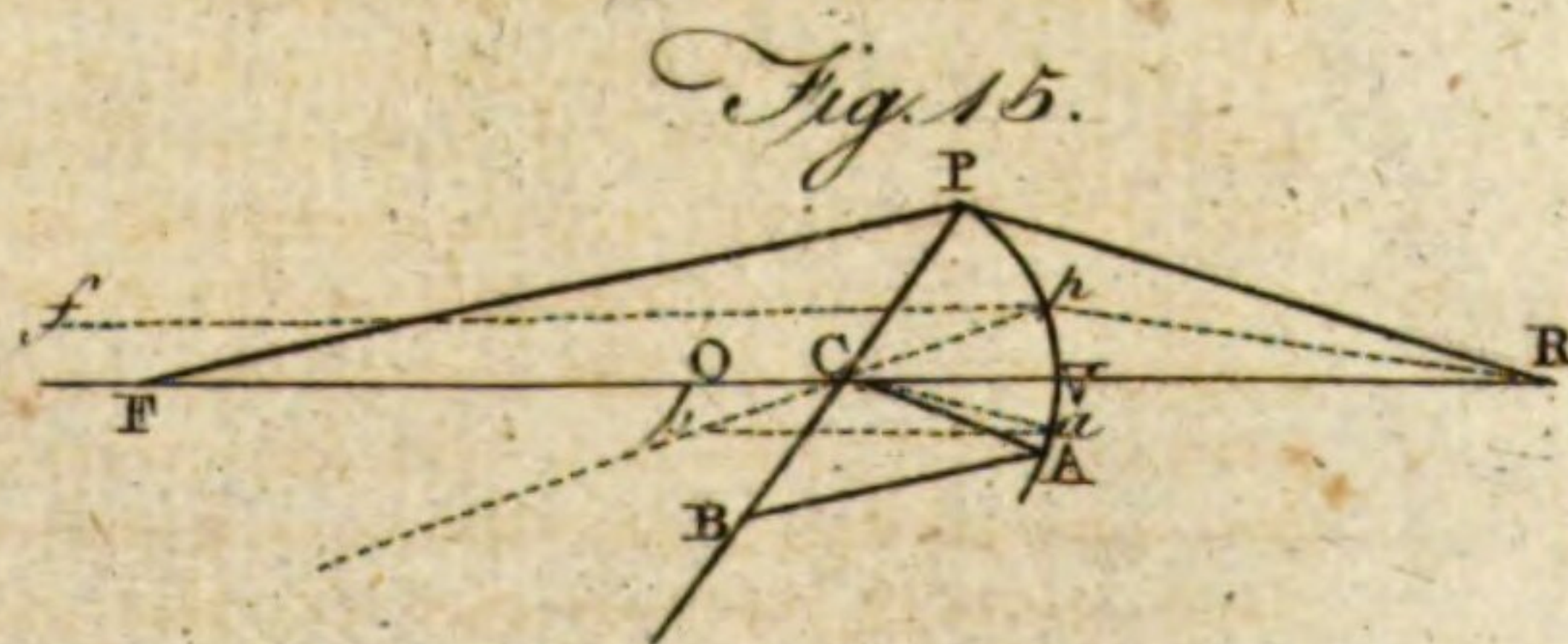
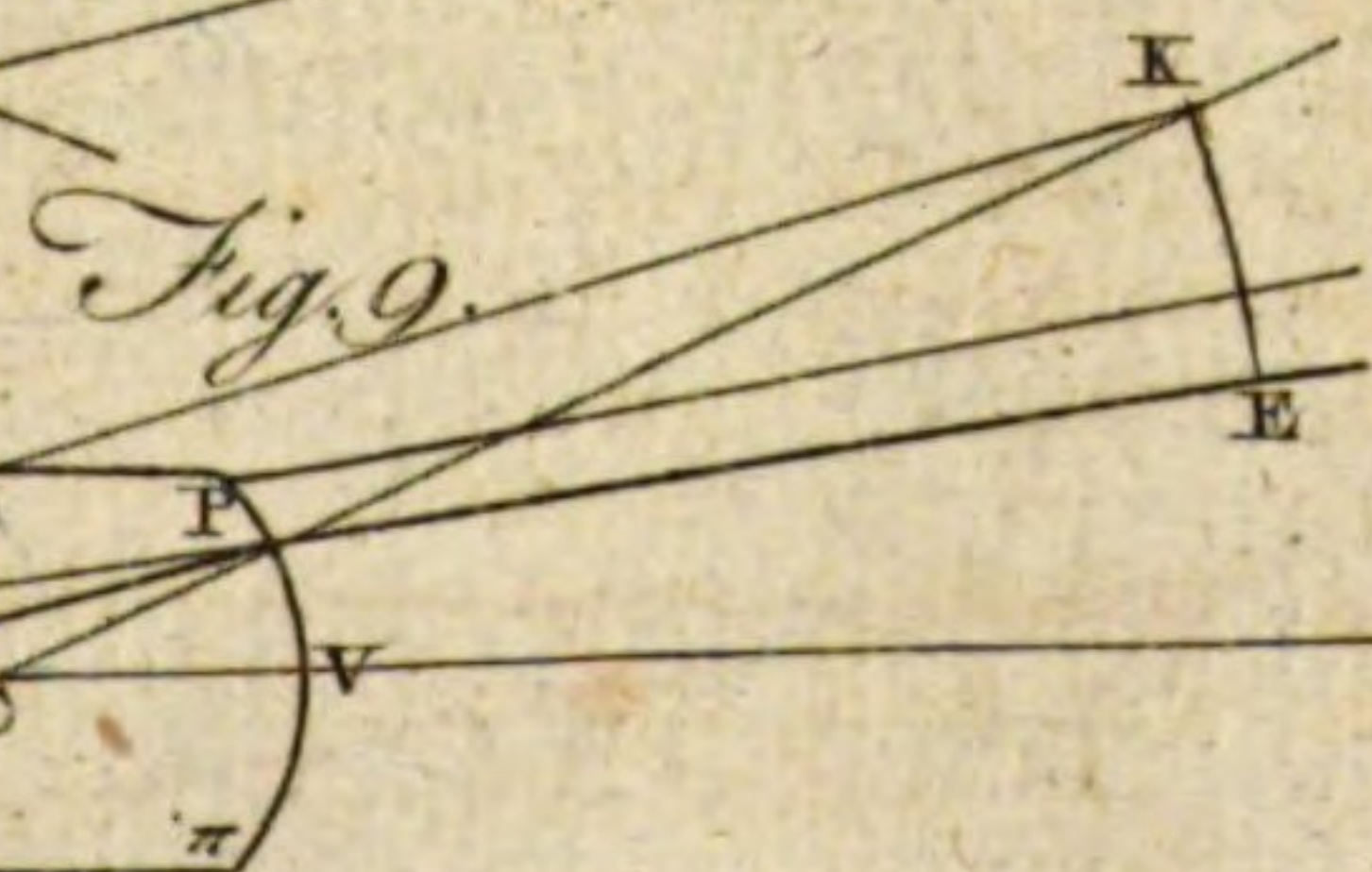
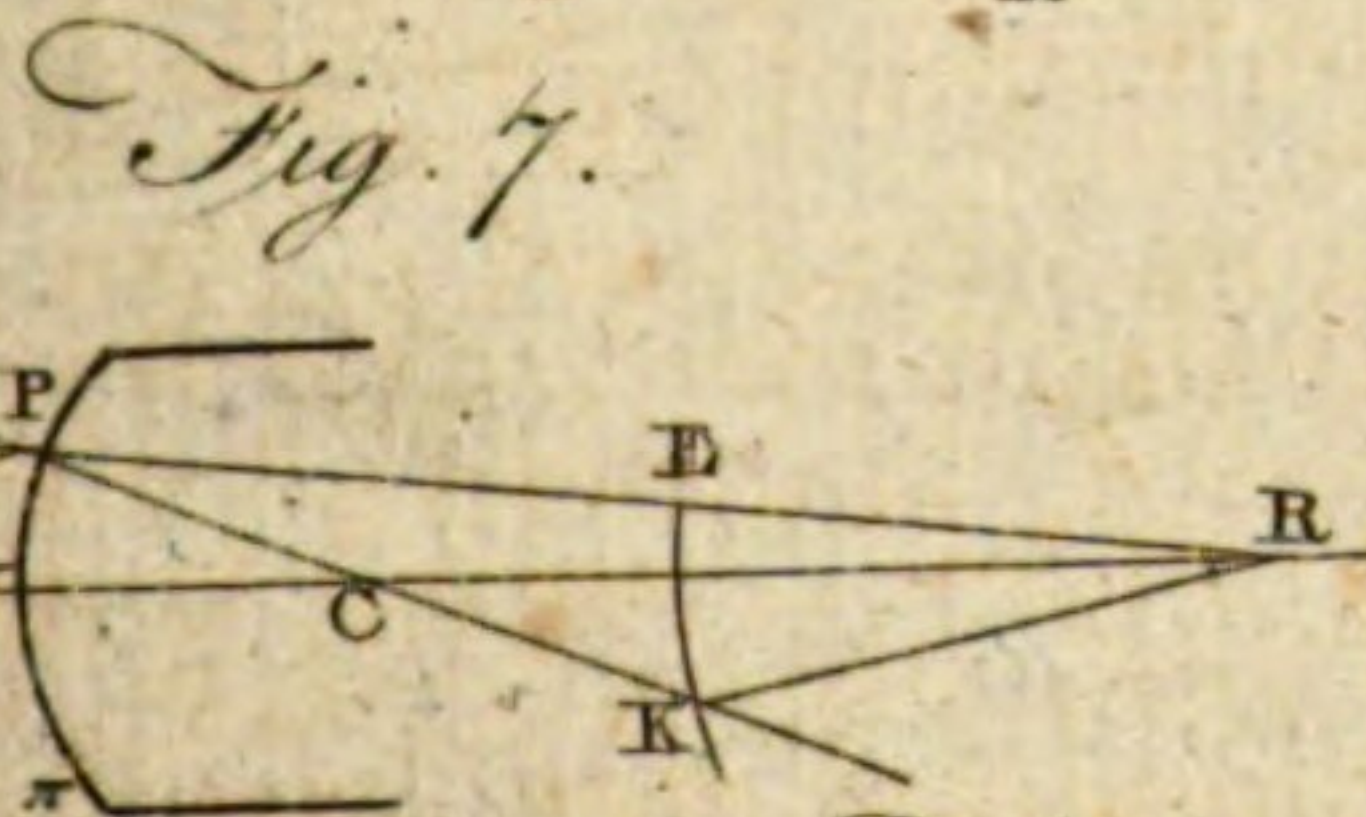
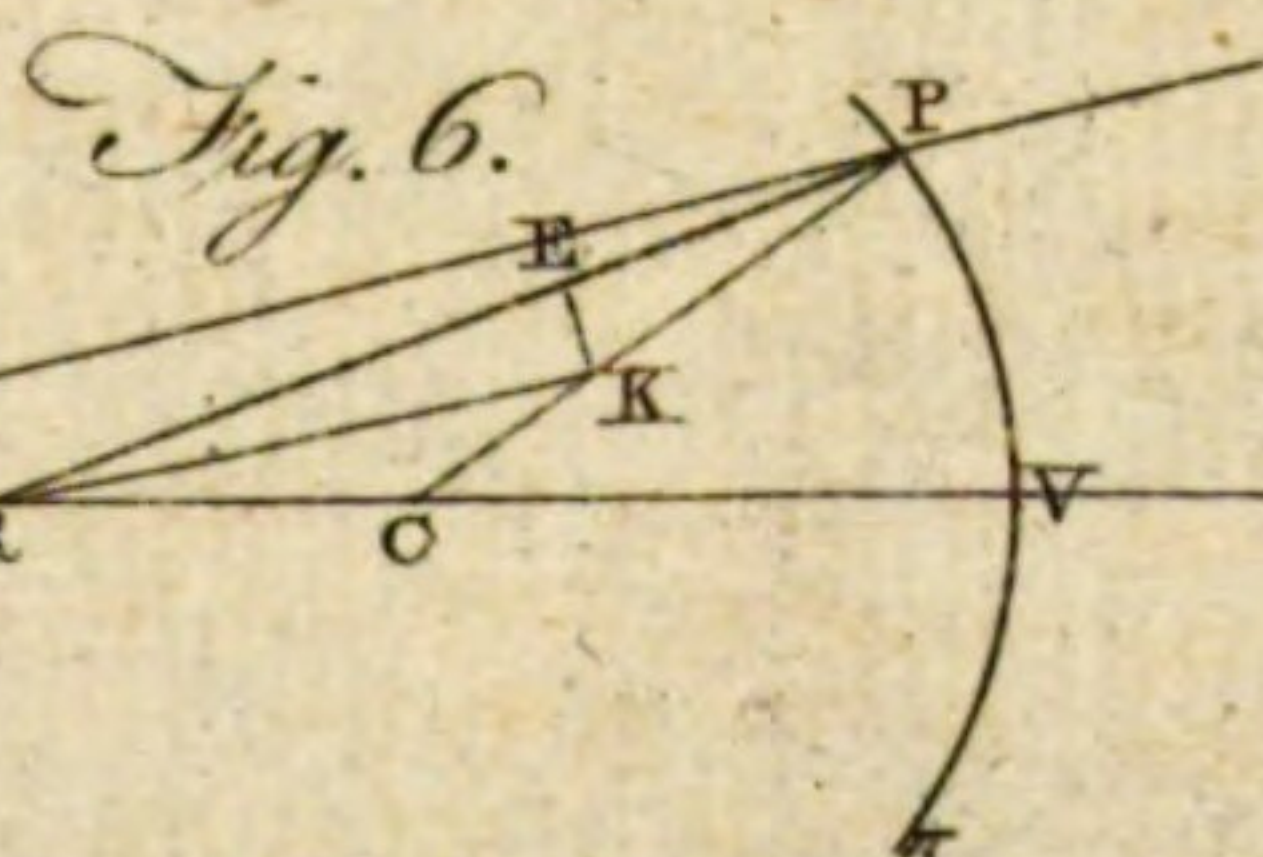
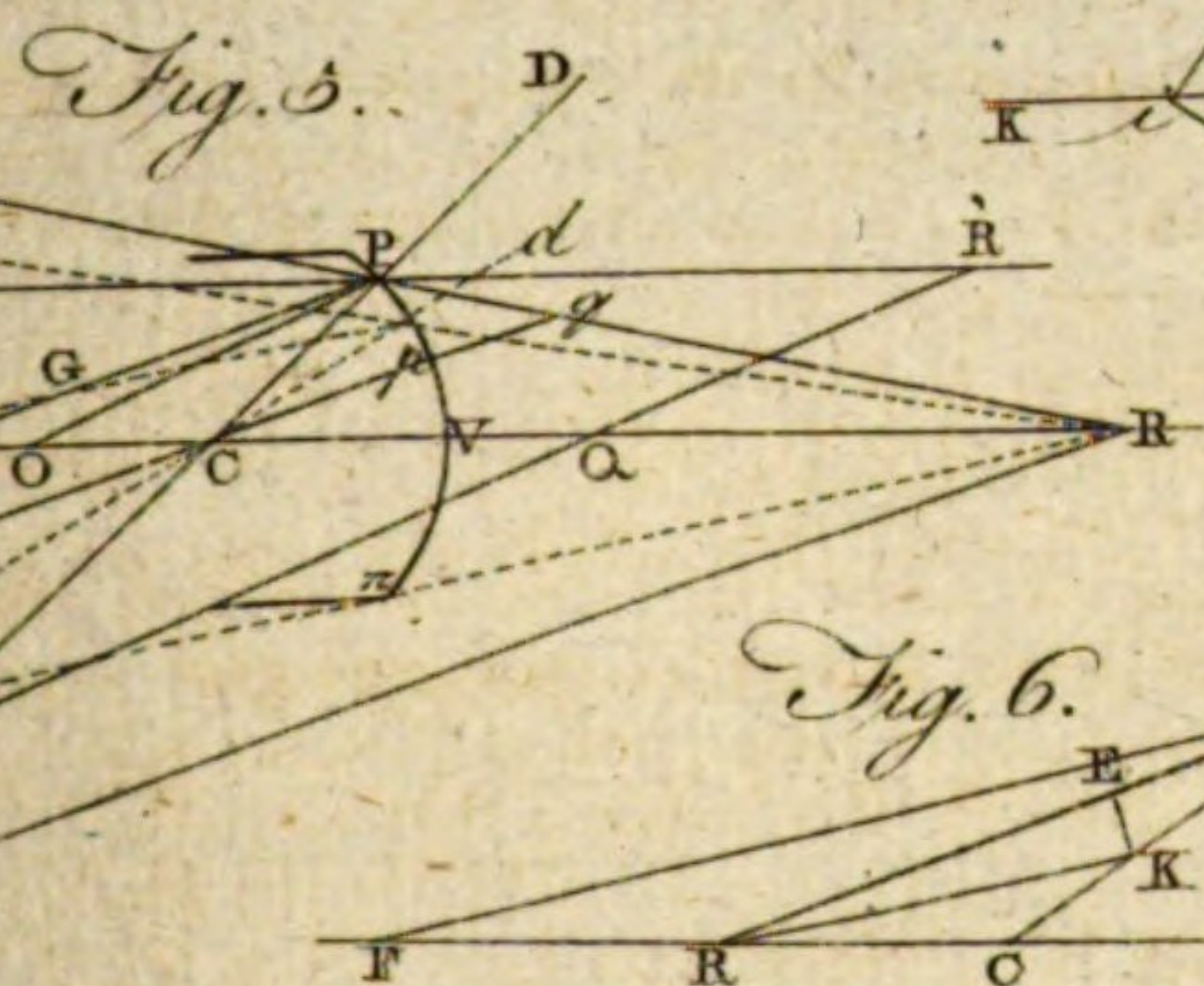
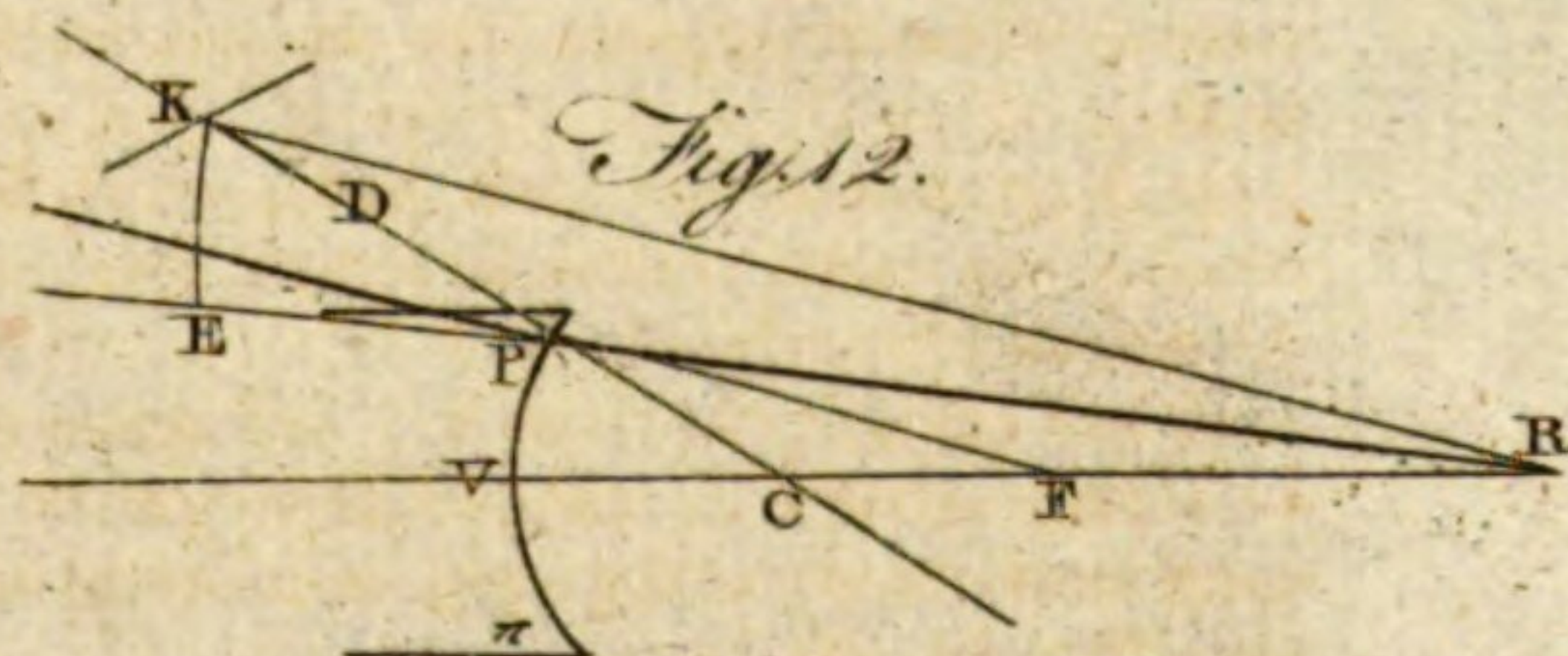
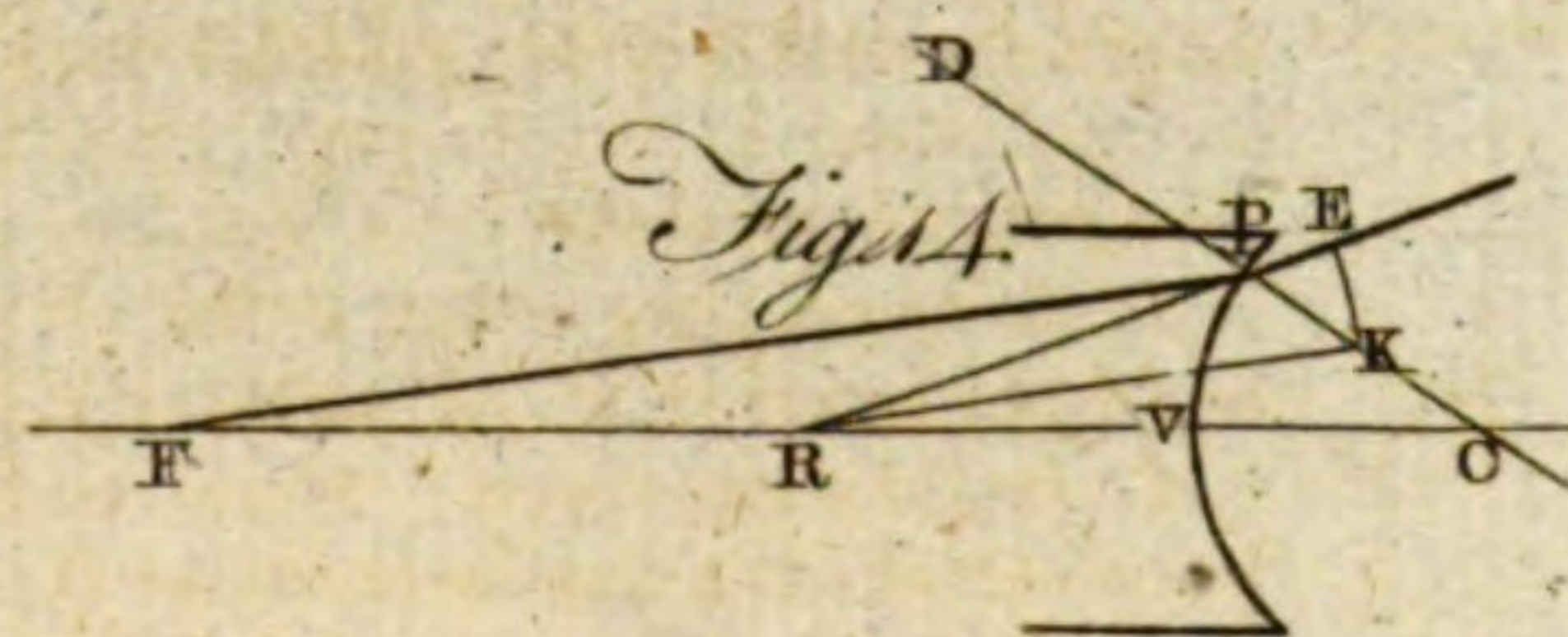
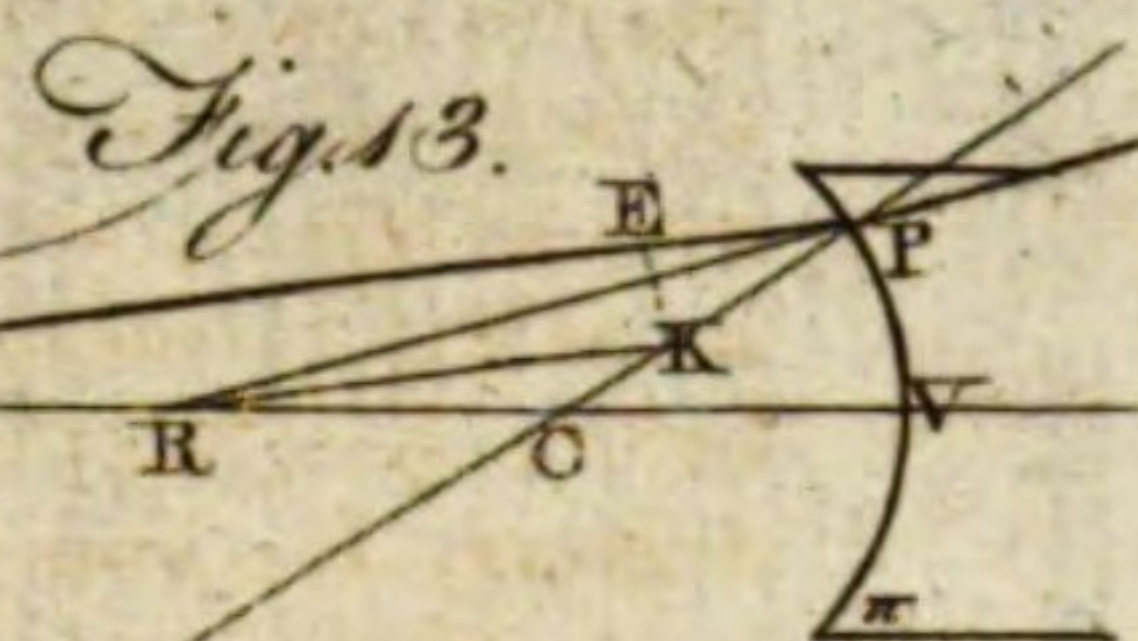
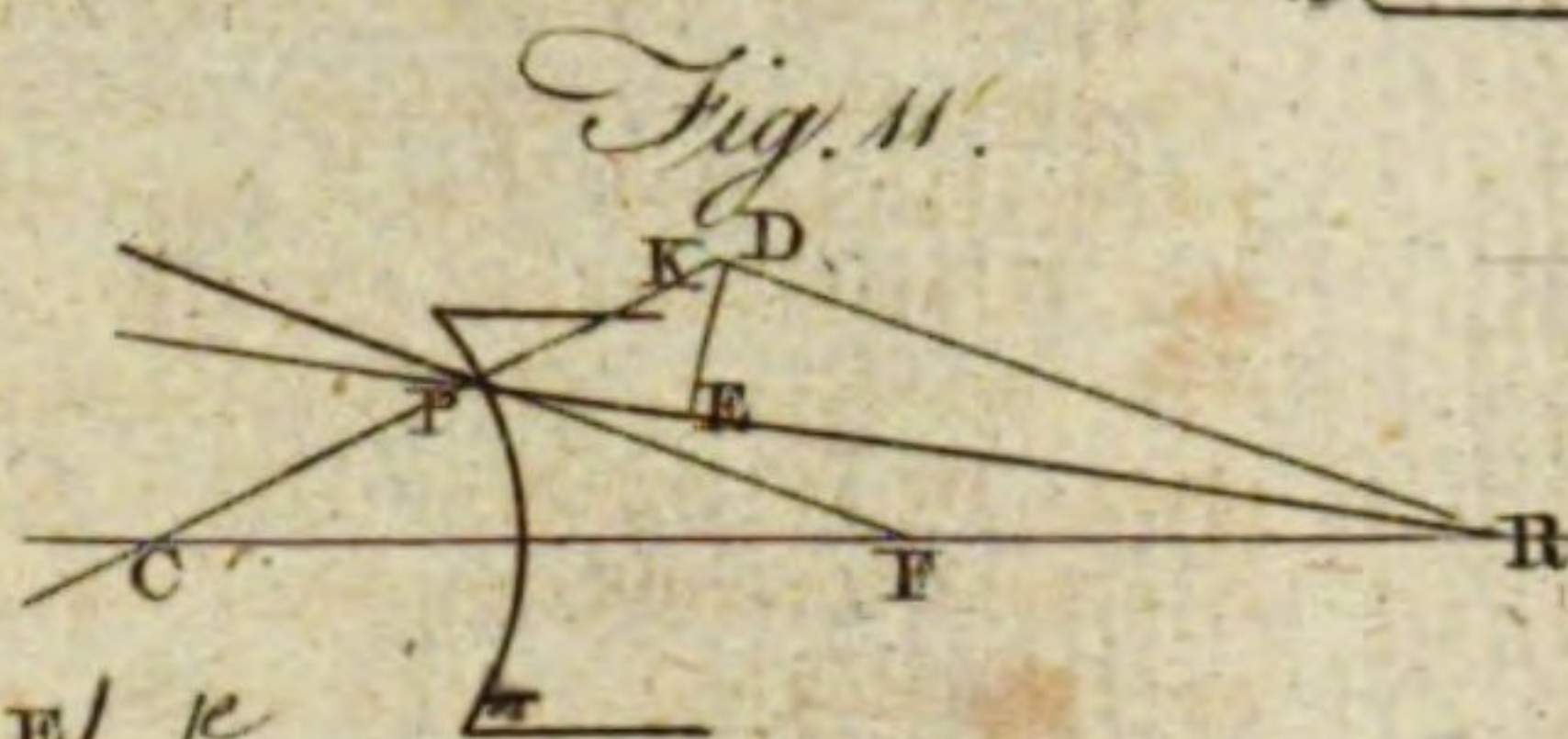
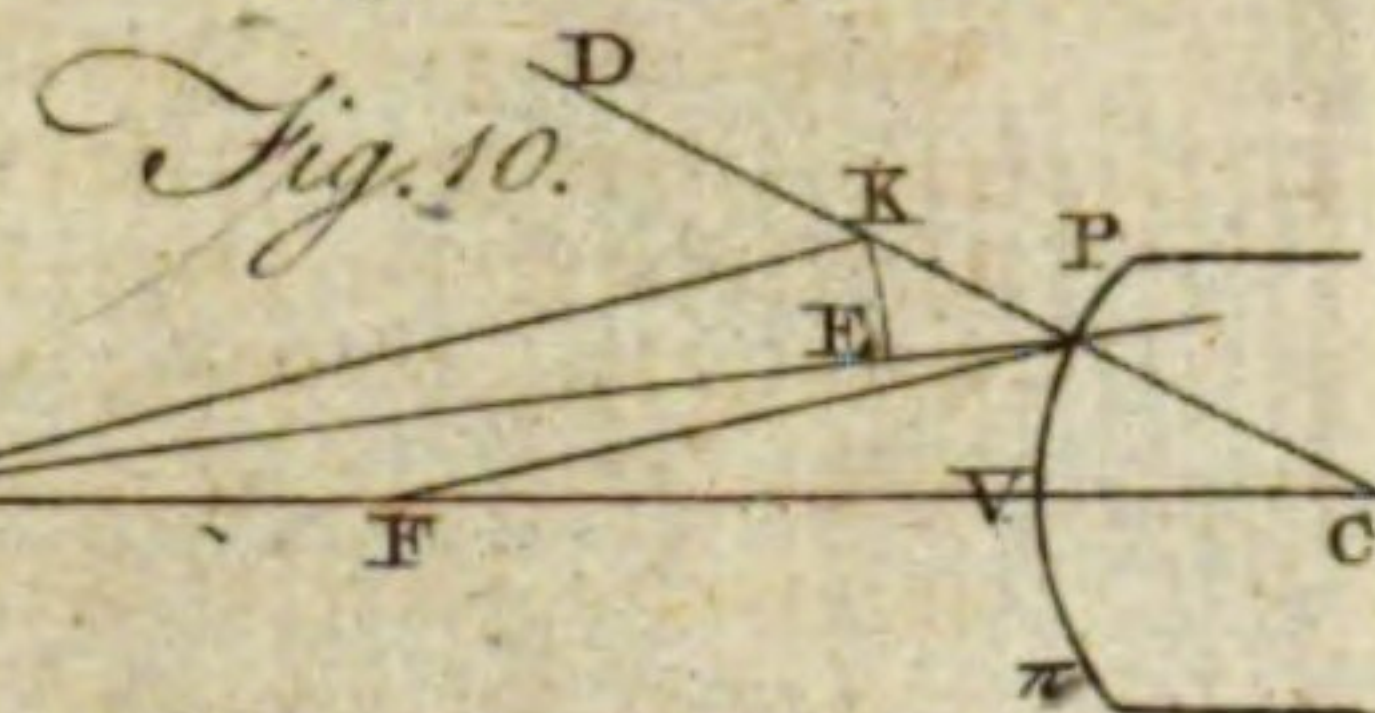
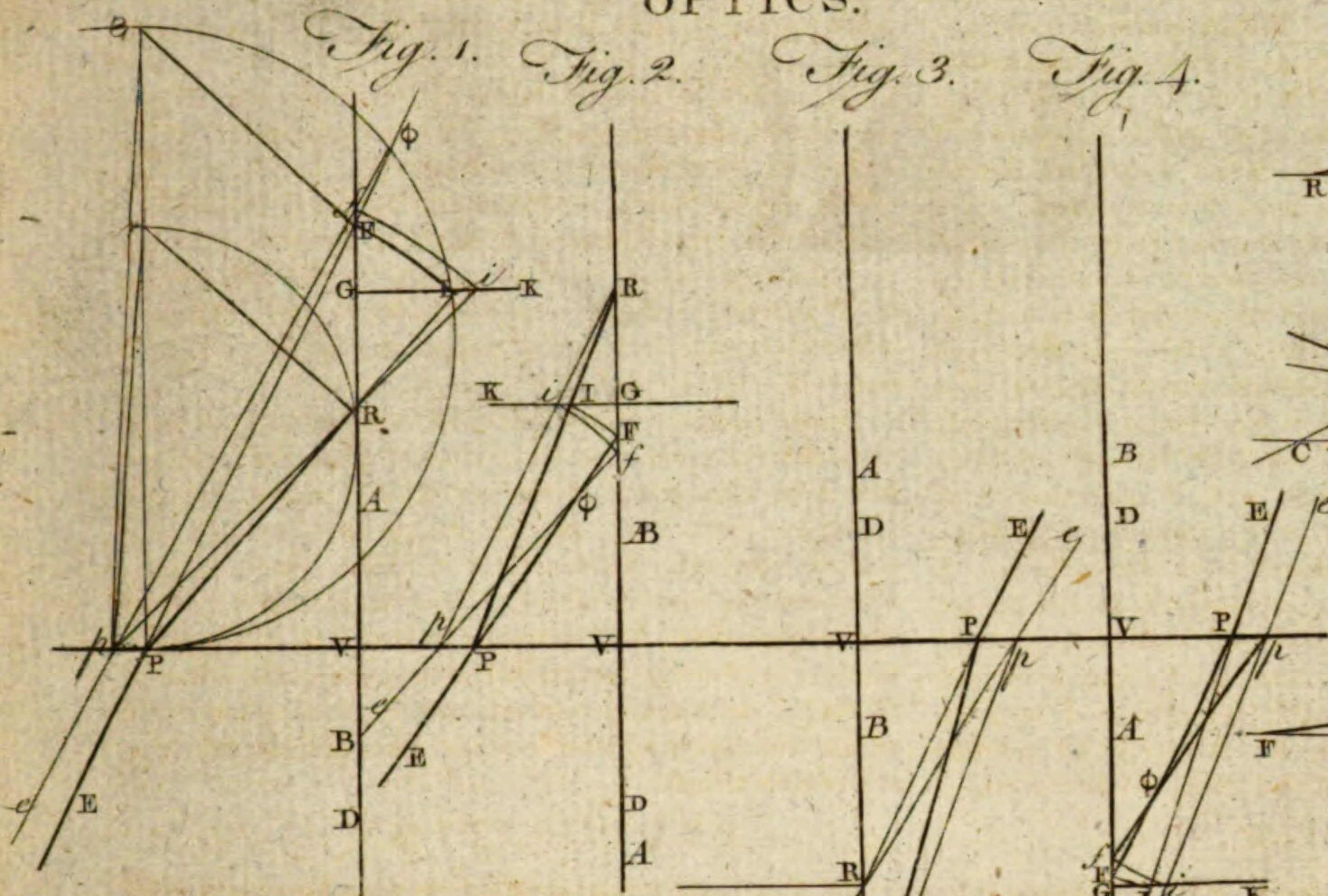
* **Corol.**
from Lemma.

* By a former Prop.

OPTICS.

Plate CCCIV.

Fig. 1. *Fig. 2.* *Fig. 3.* *Fig. 4.*



A. Bell Prin. Wal. Sculptor fecit.

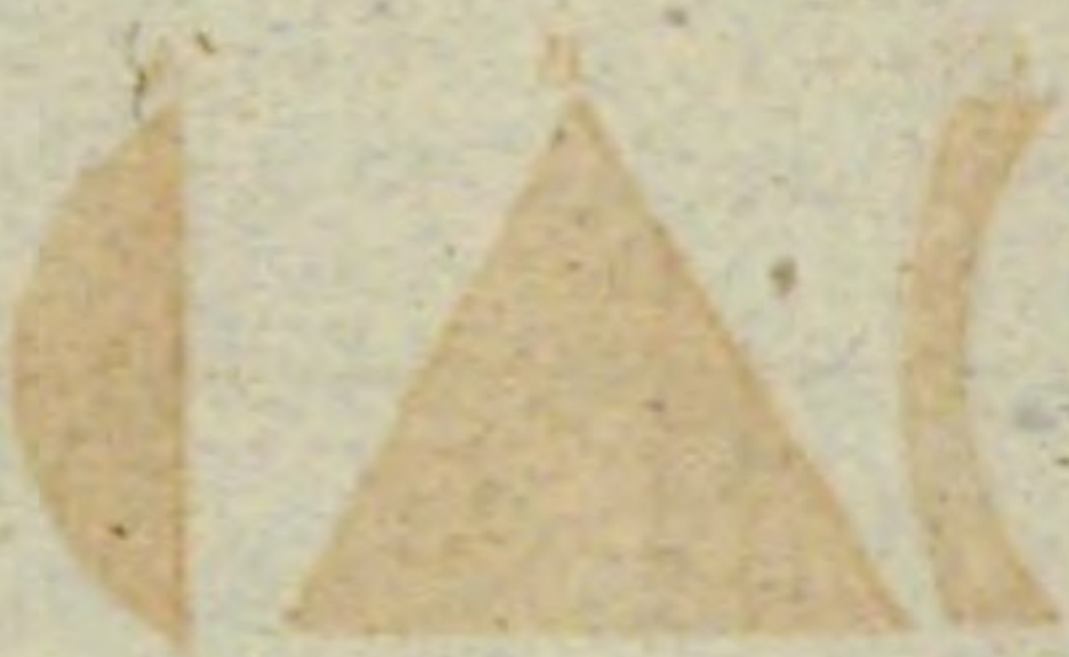


Fig. 1.

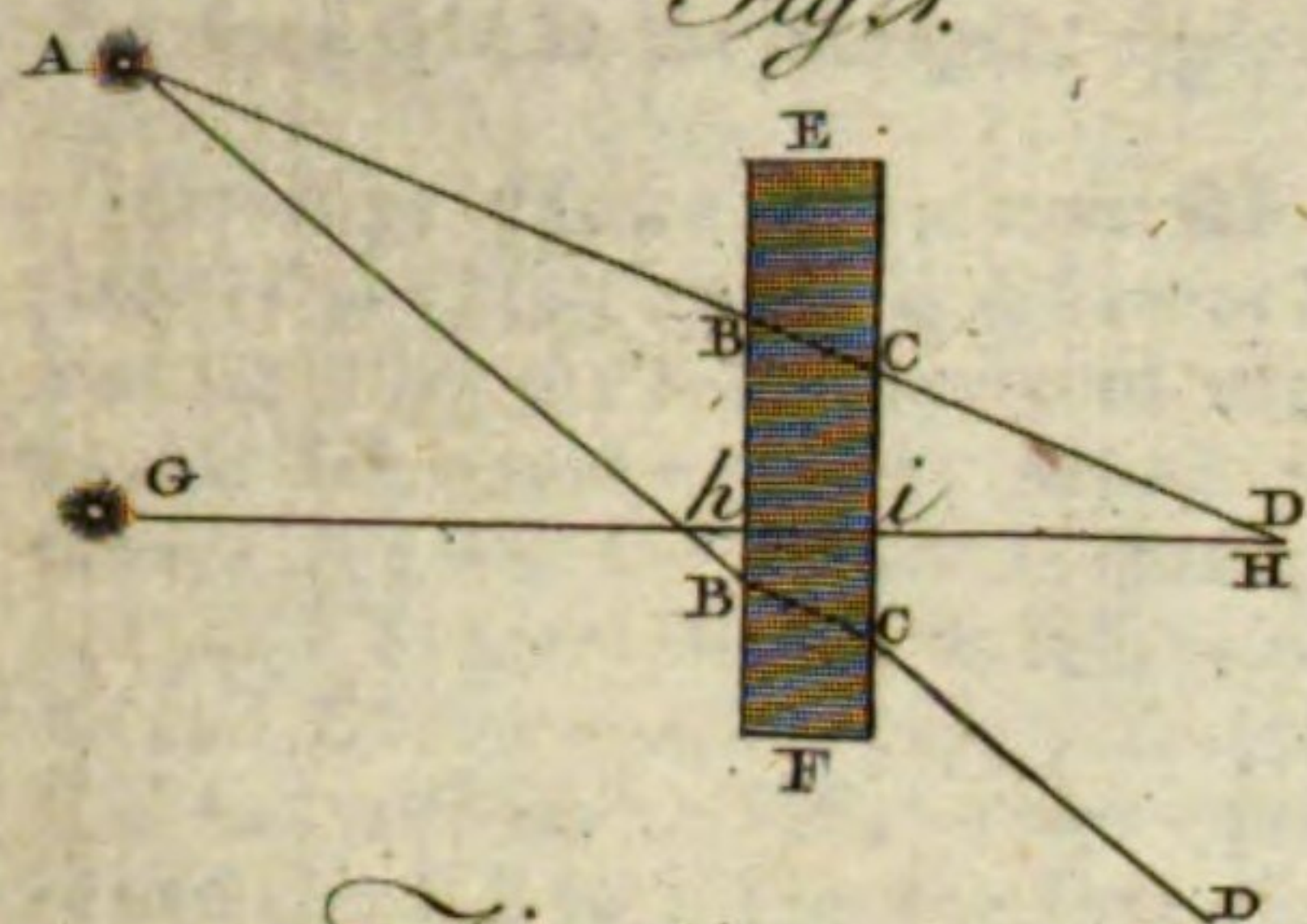


Fig. 2.

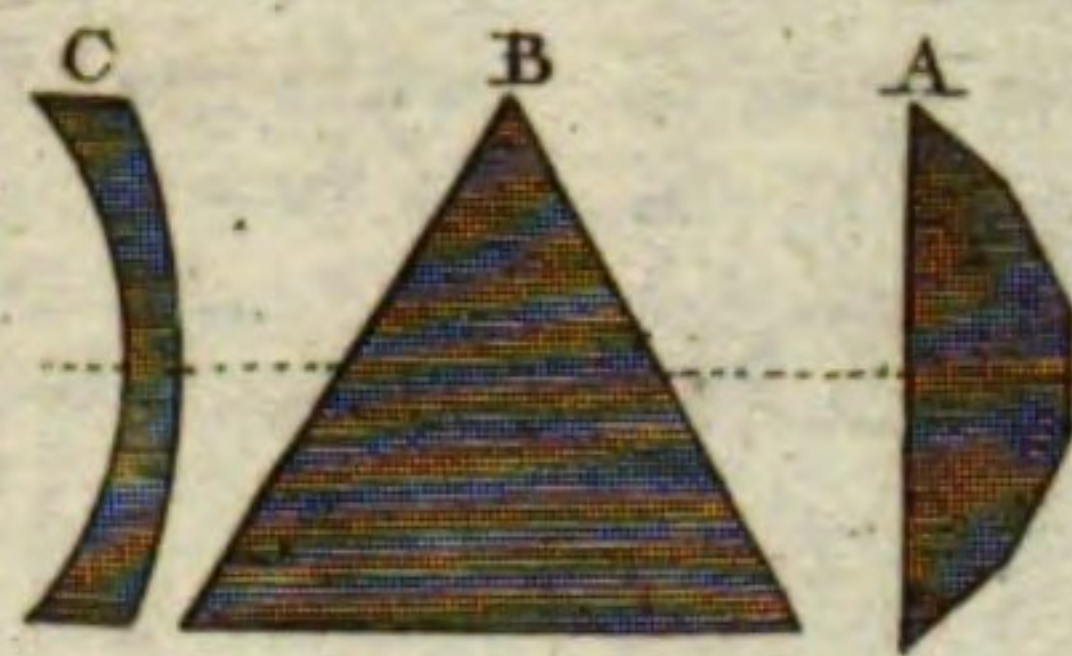


Fig. 3.

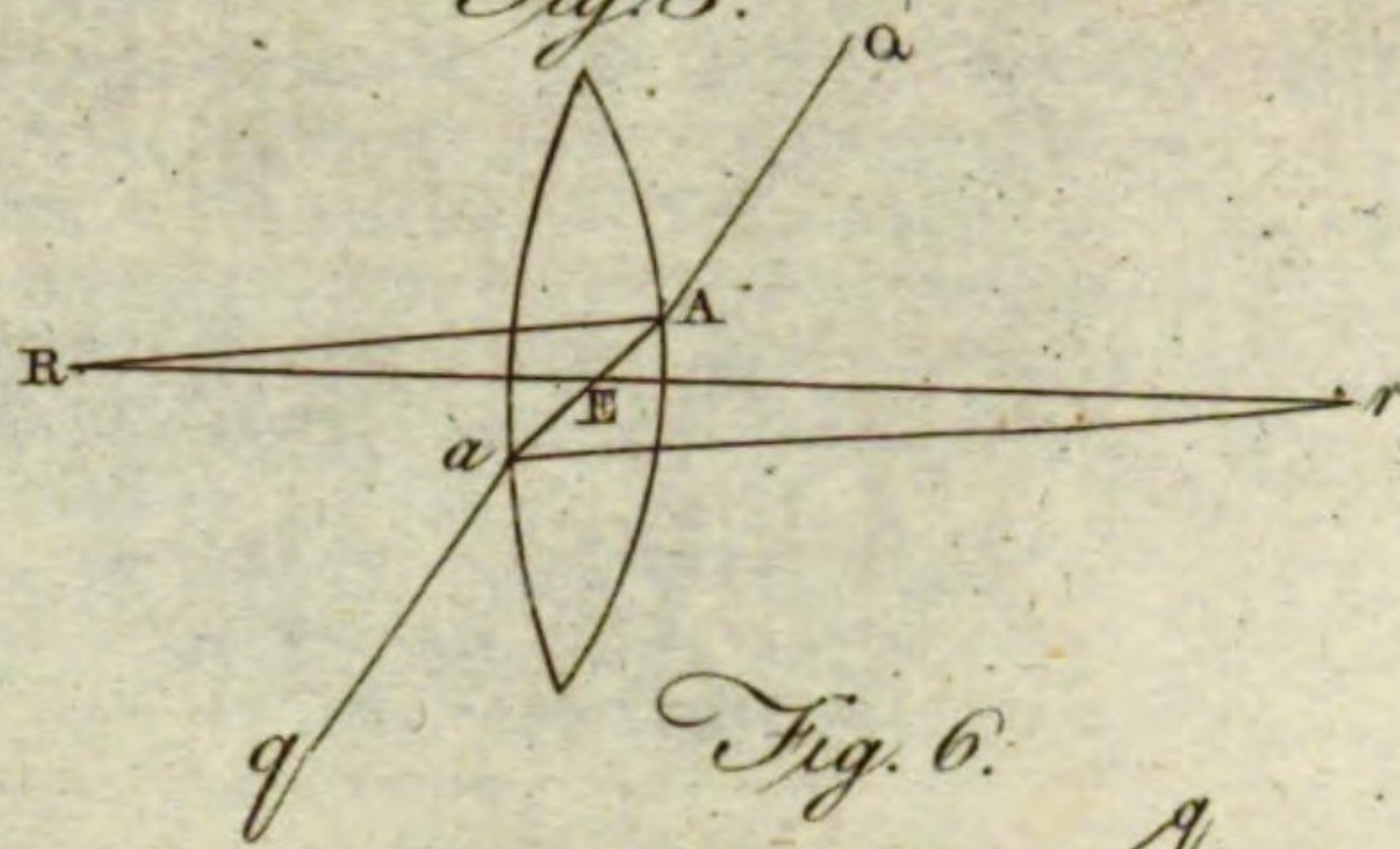


Fig. 4.

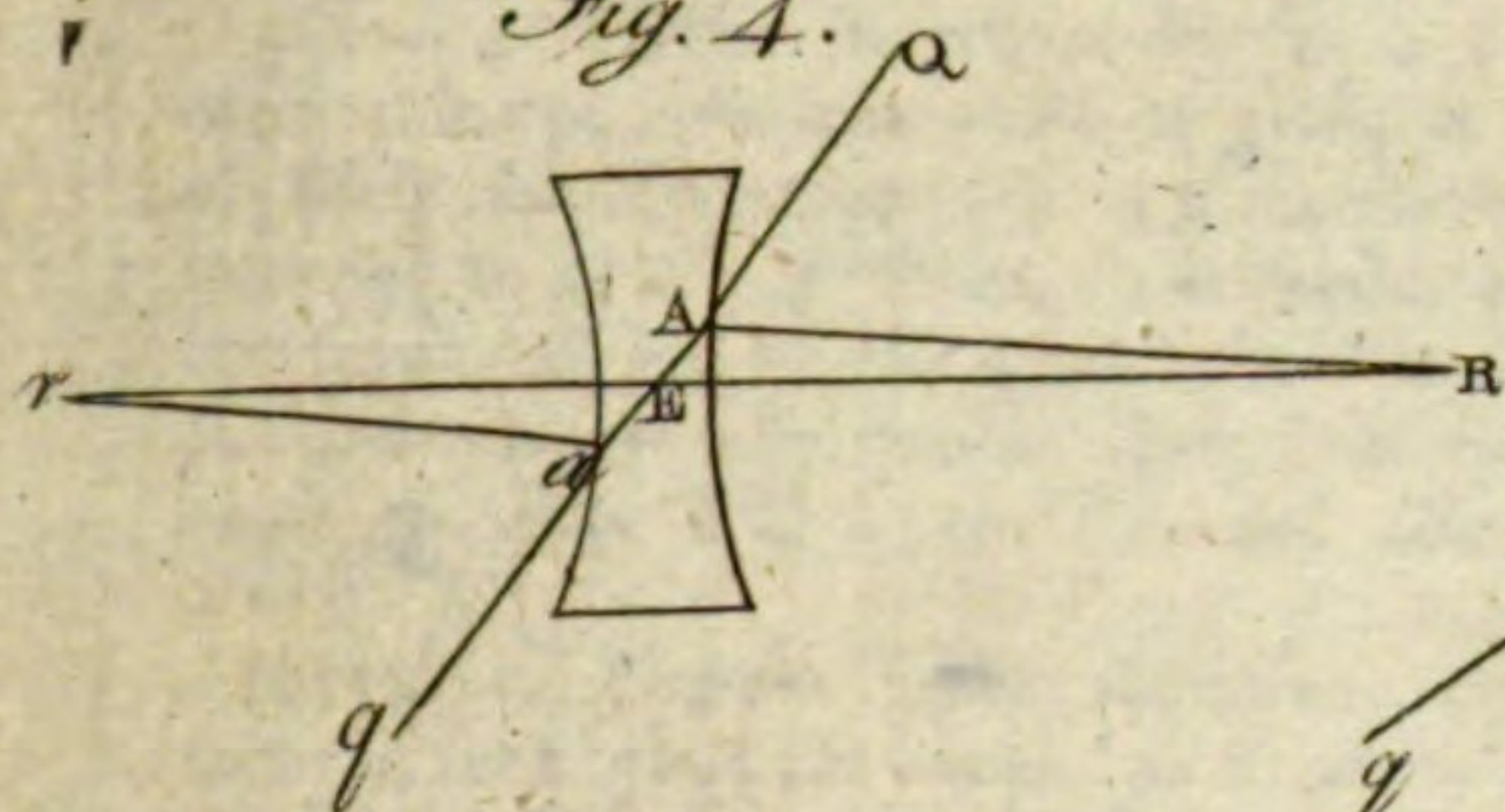


Fig. 5.

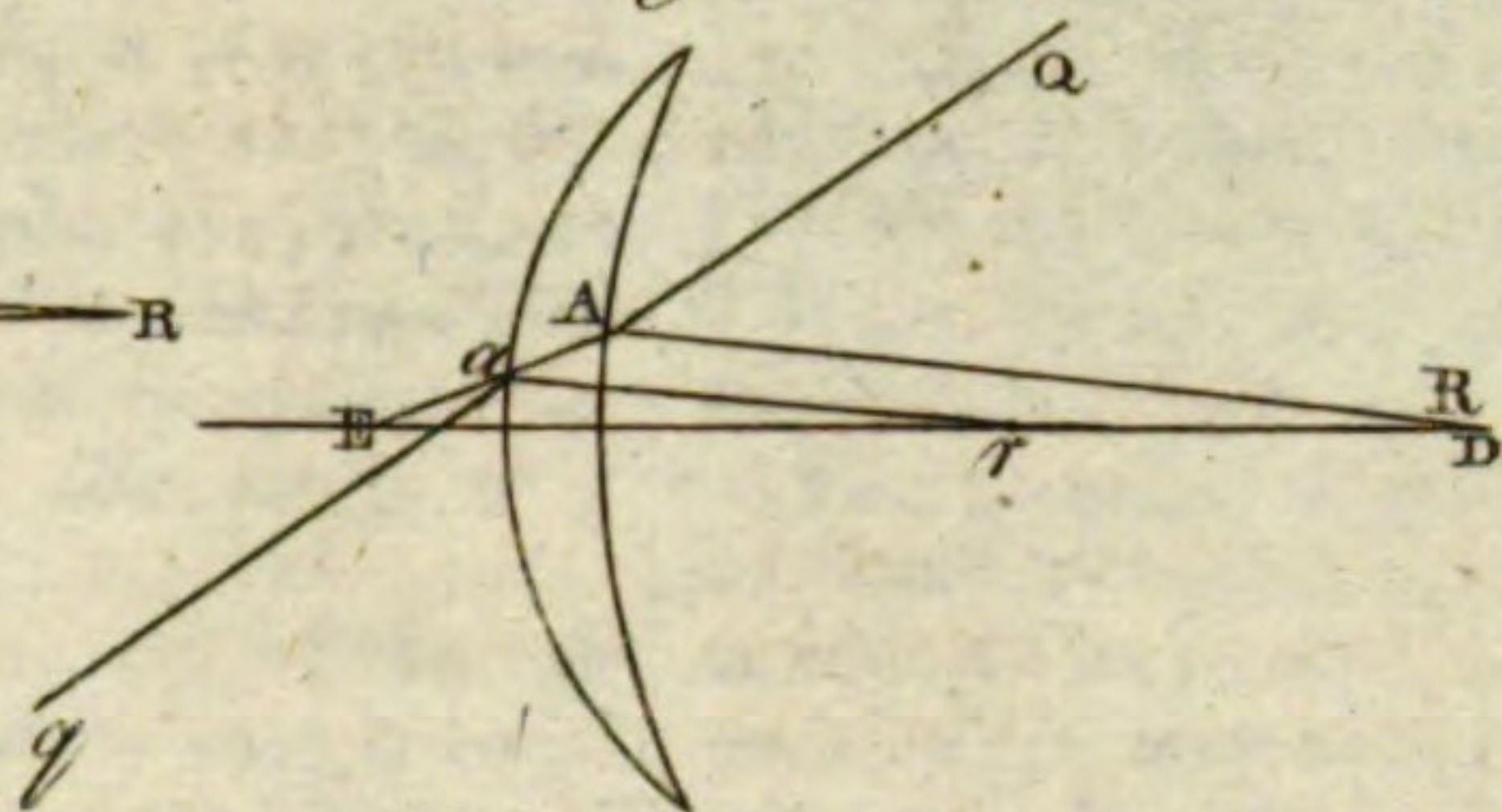


Fig. 6.

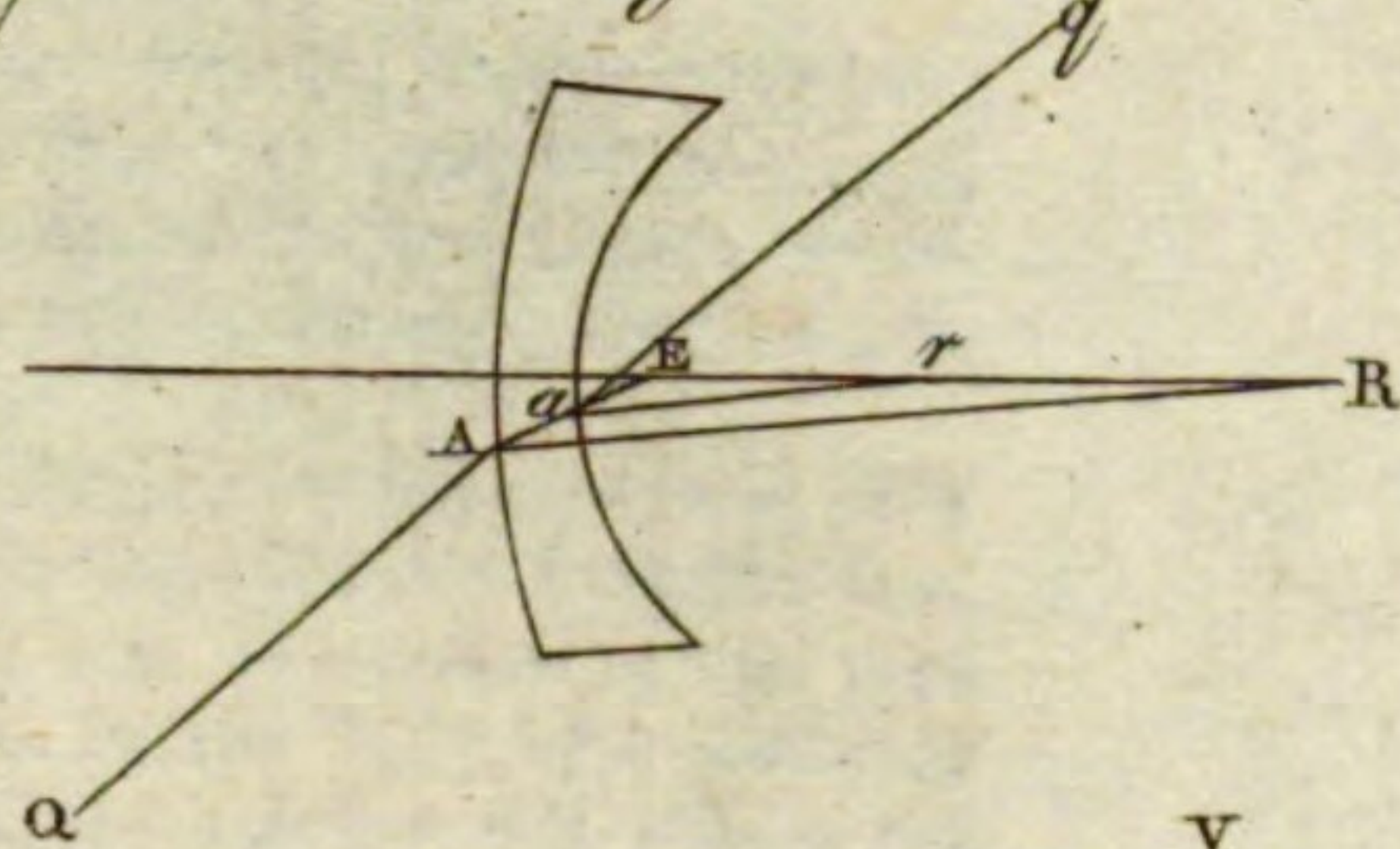


Fig. 7.

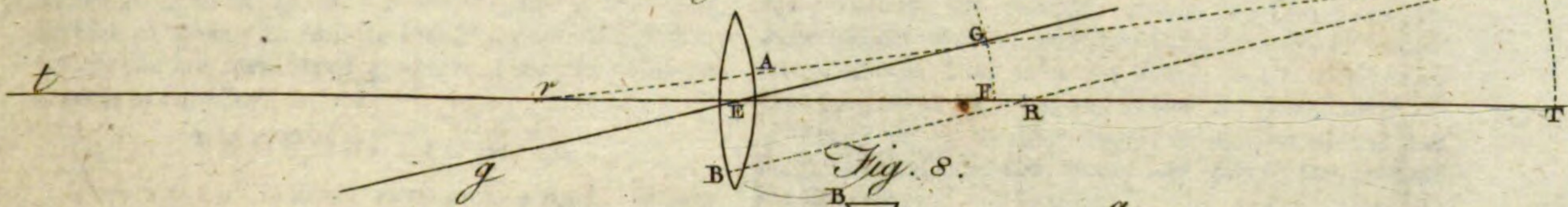


Fig. 8.

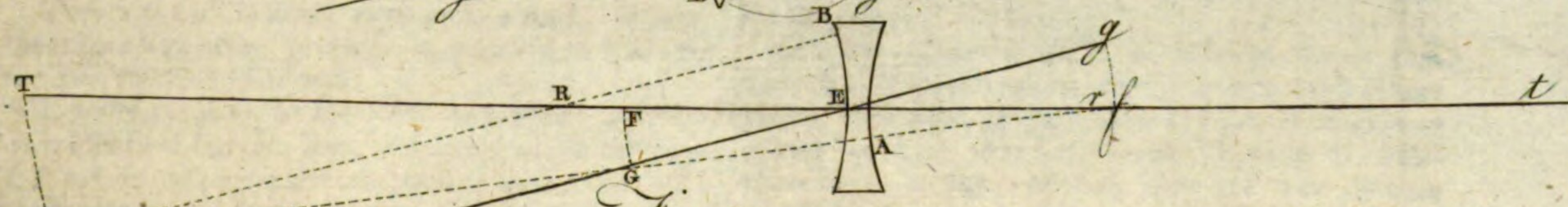


Fig. 9.

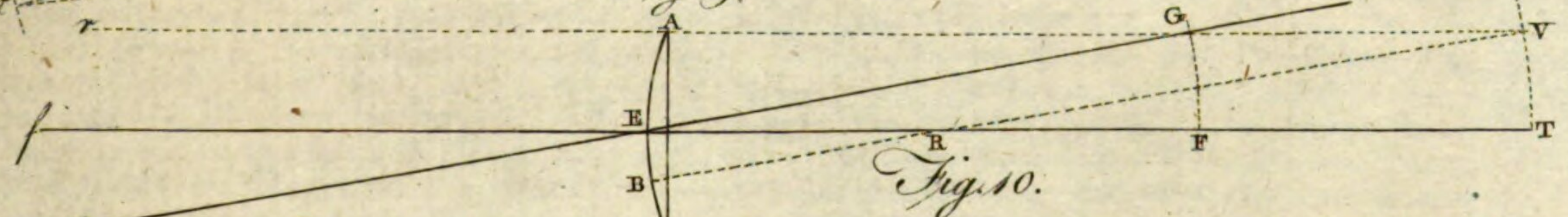


Fig. 10.

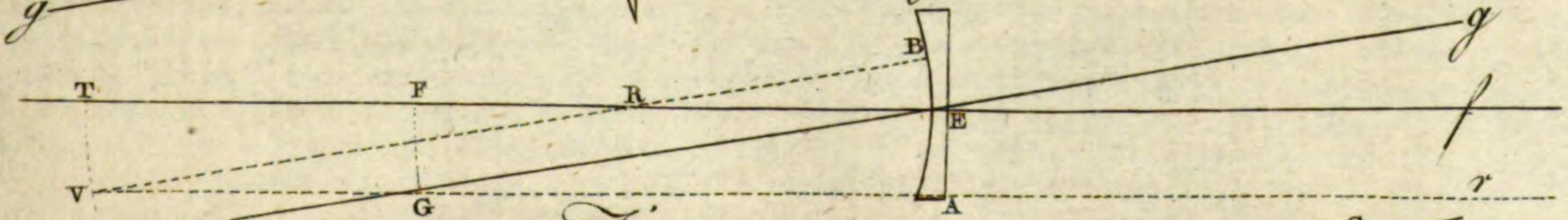


Fig. 11.



Fig. 12.

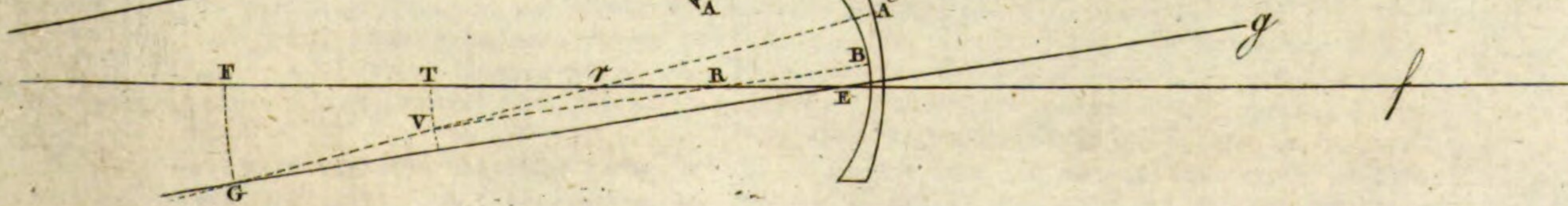


PLATE I
OF THE
OPTICS

OPTICS



Of Glasses. the same side as the emergent rays, or on the opposite side.

Corol. 3. Hence when rays fall parallel on both sides of any lens, the focal distances EF , Ef are equal. For let rt be the continuation of the semidiameter Er to the first focus t of rays falling parallel upon the surface A ; and the same rule that gave rR to rE as RT to EF , gives also rR to RE as rt to Ef . Whence Ef and EF are equal, because the rectangles under rE , RT and also under RE , rt are equal. For rE is to rt and also RE to RT in the same given ratio.

Corol. 4. Hence in particular in a double-convex or double-concave lens made of glass, it is as the sum of their semidiameters (or in a meniscus as their difference) to either of them, so is double the other, to the focal distance of the glass. For the continuations RT , rt are severally double their semidiameters: because in glass ET is to TR and also Et to tr as 3 to 2.

Corol. 5. Hence if the semidiameters of the surfaces of the glass be equal, its focal distance is equal to one of them; and is equal to the focal distance of a plano-convex or plano-concave glass whose semidiameter is as short again. For considering the plane surface as having an infinite semidiameter, the first ratio of the last mentioned proportion may be reckoned a ratio of equality.

PROPOSITION II.

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The focus
of emergent
rays found.

Plate
CCCLVII.
fig. 1. to 6.

THE focus of incident rays upon a single surface, sphere, or lens being given, it is required to find the focus of the emergent rays.

Let any point Q be the focus of incident rays upon a spherical surface, lens, or sphere, whose centre is E ; and let other rays come parallel to the line QE the contrary way to the given rays, and after refraction let them belong to a focus F ; then taking Ef equal to EF in the lens or sphere, but equal to FC in the single surface, say as QF to FE so Ef to fq ; and placing fq the contrary way from f to that of FQ from F , the point q will be the focus of the refracted rays, without sensible error; provided the point Q be not so remote from the axis, nor the surfaces so broad, as to cause any of the rays to fall too obliquely upon them.

For with the centre E and semidiameters EF and Ef describe two arches FG , fg cutting any ray $QAaq$ in G and g , and draw EG and Eg . Then supposing G to be a focus of incident rays (as GA), the emergent rays (as agg) will be parallel to GE *; and on the other hand supposing g another focus of incident rays (as ga), the emergent rays (as AGQ) will be parallel to gE . Therefore the triangles QGE , Egq are equiangular, and consequently QG is to GE as Eg to gq ; that is, when the ray $QAaq$ is the nearest to QE , QF is to FE as Ef to fg . Now when Q accedes to F and coincides with it, the emergent rays become parallel, that is q recedes to an infinite distance; and consequently when Q passes to the other side of F , the focus q will also pass through an infinite space from one side of f to the other side of it. $Q. E. D.$

Corol. 1. In a sphere or lens the focus q may be found by this rule: As QF to QE so QE to Qq , to be placed the same way from Q as QF lies from Q . For let the incident and emergent ray QA , qa be pro-

duced till they meet in e ; and the triangles QGE , Qeq being equiangular, we have QG to QE as Qe to Qq ; and when the angles of these triangles are vanishing, the point e will coincide with E ; because in the sphere the triangle Aea is equiangular at the base Aa , and consequently Ae and ae will at last become semidiameters of the sphere. In a lens the thickness Aa is inconsiderable.

The focus may also be found by this rule;— $QF : FE :: QE : Eq$, for $QG : GE :: QA : Ag$. And then the rule formerly demonstrated for single surfaces holds good for the lenses.

Corol. 2. In all cases the distance fq varies reciprocally as FQ does; and they lie contrarywise from f and F ; because the rectangle or the square under EF and Ef , the middle terms in the foregoing proportions, is invariable.

The principal focal distance of a lens may not only be found by collecting the rays coming from the sun, considered as parallel, but also (by means of this proposition) it may be found by the light of a candle or window. For, because $Qq : qA :: QE : EG$, we have (when A coincides with E) $Qq : qE = QE : EF$; that is, the distance observed between the radiant object and its picture in the focus is to the distance of the lens from the focus as the distance of the lens from the radiant is to its principal focal distance. Multiply therefore the distances of the lens from the radiant and focus, and divide the product by their sum.

Corol. 3. Convex lenses of different shapes that have equal focal distances, when put into each others places, have equal powers upon any pencil of rays to refract them to the same focus. Because the rules above-mentioned depend only upon the focal distance of the lens, and not upon the proportion of the semidiameters of its surfaces.

Corol. 4. The rule that was given for a sphere of an uniform density, will serve also for finding the focus of a pencil of rays refracted through any number of concentric surfaces, which intercede uniform mediums of any different densities. For when rays come parallel to any line drawn through the common centre of these mediums, and are refracted through them all, the distance of their focus from that centre is invariable, as in an uniform sphere.

Corol. 5. When the focuses Q , q lie on the same side of the refracting surfaces, if the incident rays flow from Q , the refracted rays will also flow from q ; and if the incident rays flow towards Q , the refracted will also flow towards q : and the contrary will happen when Q and q are on contrary sides of the refracting surfaces. Because the rays are continually going forwards.

From this proposition we also derive an easy method of drawing the progress of rays through any number of lenses ranged on a common axis.

Let A , B , C , (fig. 7.) be the lenses, and RA a ray incident on the first of them. Let α , β , γ be their foci for parallel rays coming in the opposite direction; draw the perpendicular ad , cutting the incident ray in d , and draw da through the centre of the lens: AB parallel to da will be the ray refracted by the first lens. Through the focus of the second lens draw the perpendicular βe , cutting AB in

* By Corol. from former Prop.

Of Vision. *ef*; and draw *eb* through the centre of the second lens. BD parallel to *be* will be the next refracted ray. Through the focus *x* of the third lens draw the perpendicular *xf*, cutting BD in *f*, and draw *fc* through the centre of the third lens. CE parallel to *fc* will be the refracted ray; and so on.

§ 3. *Of Vision.*

HAVING described how the rays of light, flowing from objects, and passing through convex glasses, are collected into points, and form the images of the objects; it will be easy to understand how the rays are affected by passing through the humours of the eye, and are thereby collected into innumerable points on the bottom of the eye, and thereon form the images of the objects which they flow from. For, the different humours of the eye, and particularly the crystalline humour, are to be considered as a convex glass; and the rays in passing through them to be affected in the same manner as in passing through a convex glass. A description of the coats and humours, &c. has been given at large in ANATOMY: but for the reader's convenience in this place, we shall repeat in a few words as much of the description as will be sufficient for our present purpose.

Plate
CCCLVII.
fig. 8.
145
Description
of the eye.

The eye is nearly globular. It consists of three coats and three humours. The part DHHG of the outer coat, is called the *sclerotica*; the rest, DEFG, the *cornea*. Next within this coat is that called the *choroides*, which serves as it were for a lining to the other, and joins with the iris, *mn*, *mn*. The iris is composed of two sets of muscular fibres; the one of a circular form, which contracts the hole in the middle called the *pupil*, when the light would otherwise be too strong for the eye; and the other of radial fibres, tending everywhere from the circumference of the iris towards the middle of the pupil; which fibres, by their contraction, dilate and enlarge the pupil when the light is weak, in order to let in the more of its rays. The third coat is only a fine expansion of the optic nerve L, which spreads like net-work all over the inside of the choroides, and is therefore called the *retina*; upon which are painted (as it were) the images of all visible objects, by the rays of light which either flow or are reflected from them.

Under the cornea is a fine transparent fluid like water, which is therefore called the *aqueous humour*. It gives a protuberant figure to the cornea, fills the two cavities *mm* and *nn*, which communicate by the pupil P; and has the same limpidity, specific gravity, and refractive power, as water. At the back of this lies the crystalline humour II, which is shaped like a double convex glass; and is a little more convex on the back than the fore-part. It converges the rays, which pass through it from every visible object to its focus at the bottom of the eye. This humour is transparent like crystal, is much of the consistence of hard jelly, and exceeds the specific gravity of water in the proportion of 11 to 10. It is inclosed in a fine transparent membrane, from which proceed radial fibres *oo*, called the *ligamentum ciliare*, all around its edge; and join to the circumference of the iris.

At the back of the crystalline, lies the vitreous humour KK, which is transparent like glass, and is largest of all in quantity, filling the whole orb of the

eye, and giving it a globular shape. It is much of a consistence with the white of an egg, and very little exceeds the specific gravity and refractive power of water.

As every point of an object ABC, (*ibid.*) sends out rays in all directions, some rays, from every point on the side next the eye, will fall upon the cornea between E and F; and by passing on through the humours and pupil of the eye, they will be converged to as many points on the retina or bottom of the eye, and will thereon form a distinct inverted picture *cba* of the object. Thus, the pencil of rays *qrs* that flows from the point A of the object, will be converged to the point *a* on the retina; those from the point B will be converged to the point *b*; those from the point C will be converged to the point *c*; and so of all the intermediate points: by which means the whole image *abc* is formed, and the object made visible. Although it must be owned, that the method by which this sensation is carried from the eye by the optic nerve to the common sensory in the brain, and there discerned, is above the reach of our comprehension.

But that vision is effected in this manner, may be demonstrated experimentally. Take a bullock's eye whilst it is fresh; and having cut off the three coats from the back-part, quite to the vitreous humour, put a piece of white paper over that part, and hold the eye towards any bright object, and you will see an inverted picture of the object upon the paper.

Since the image is inverted, many have wondered why the object appears upright. But we are to consider, 1. That *inverted* is only a relative term: and, 2. That there is a very great difference between the real object and the means or image by which we perceive it. When all the parts of a distant prospect are painted upon the retina, they are all right with respect to one another, as well as the parts of the prospect itself; and we can only judge of an object's being inverted, when it is turned reverse to its natural position with respect to other objects which we see and compare it with.—If we lay hold of an upright stick in the dark, we can tell which is the upper or lower part of it, by moving our hand downward or upward; and know very well that we cannot feel the upper end by moving our hand downward. Just so we find by experience, that upon directing our eyes towards a tall object, we cannot see its top by turning our eyes downward, nor its foot by turning our eyes upward; but must trace the object the same way by the eye to see it from head to foot, as we do by the hand to feel it; and as the judgment is informed by the motion of the hand in one case, so it is also by the motion of the eye in the other.

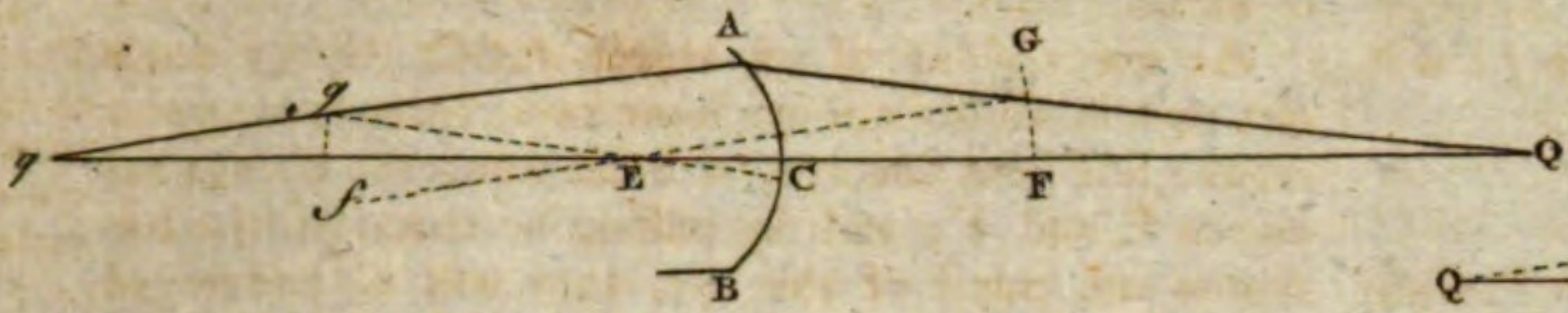
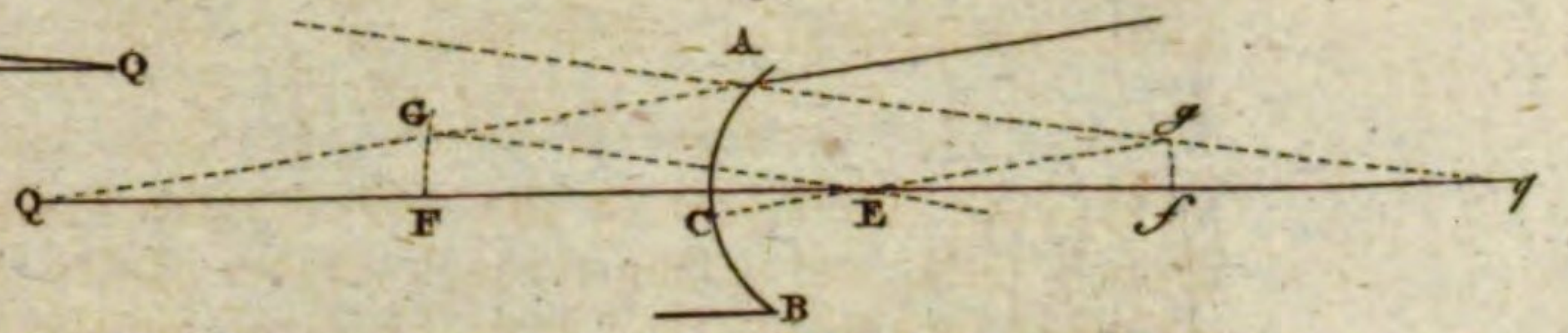
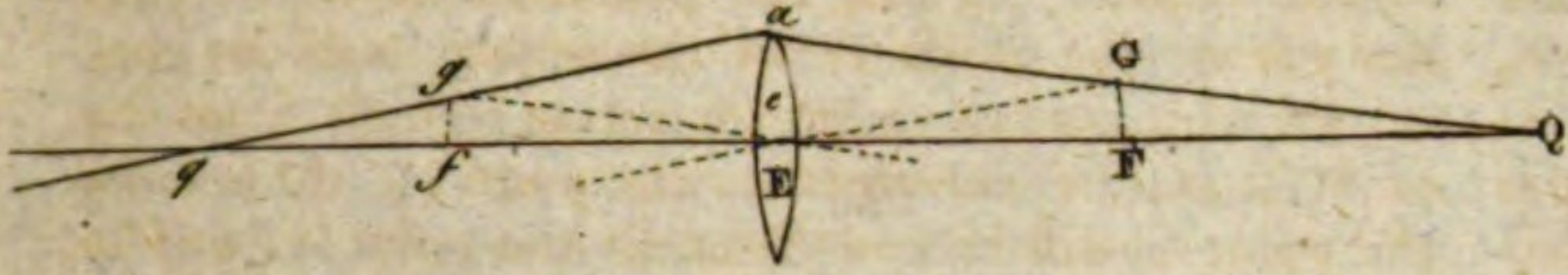
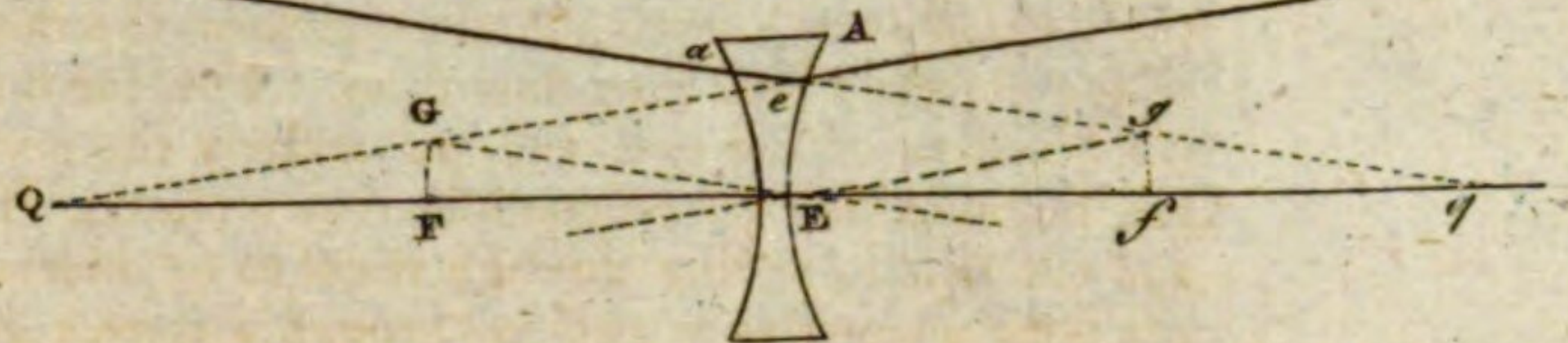
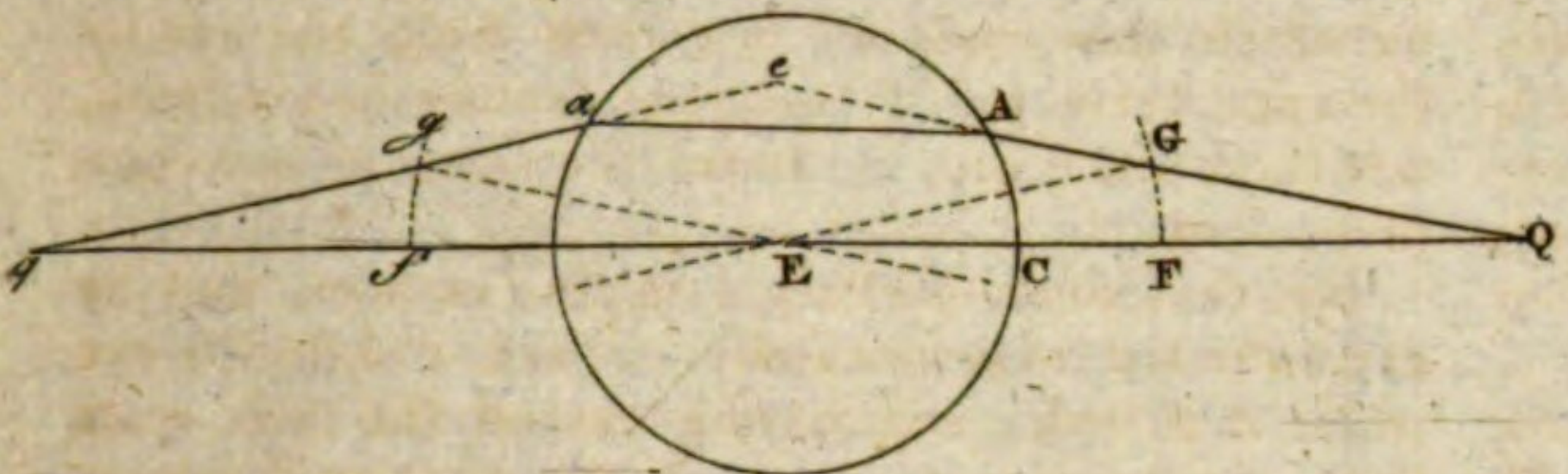
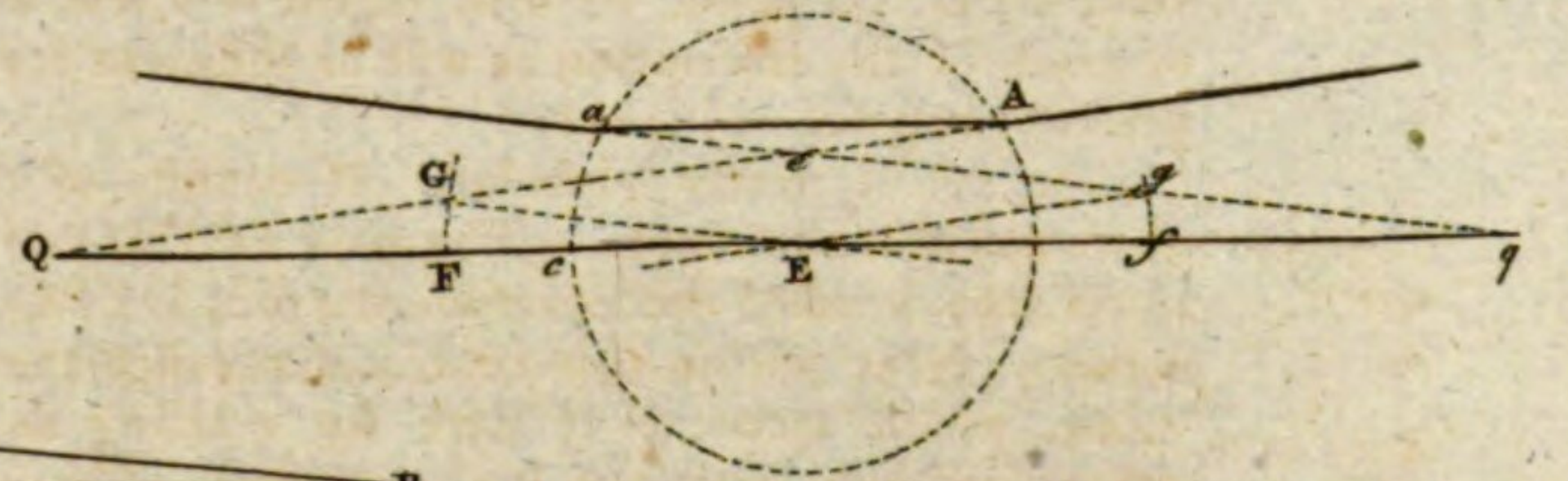
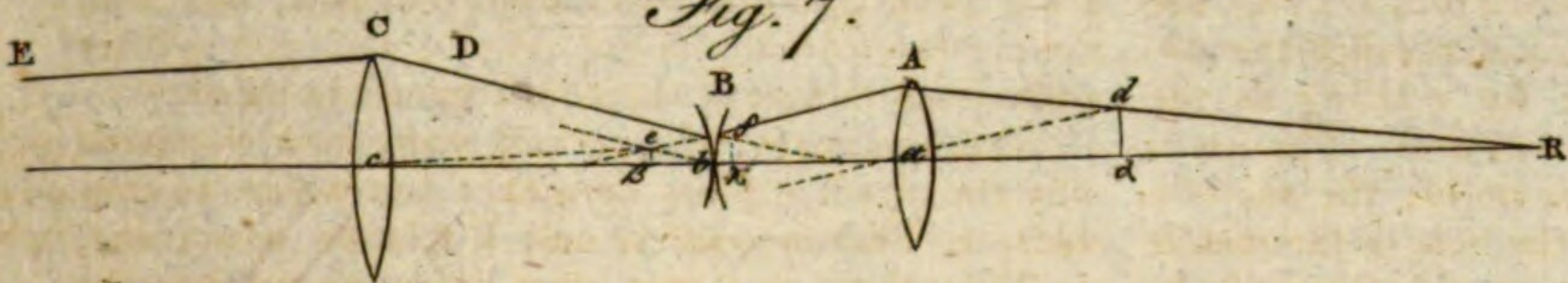
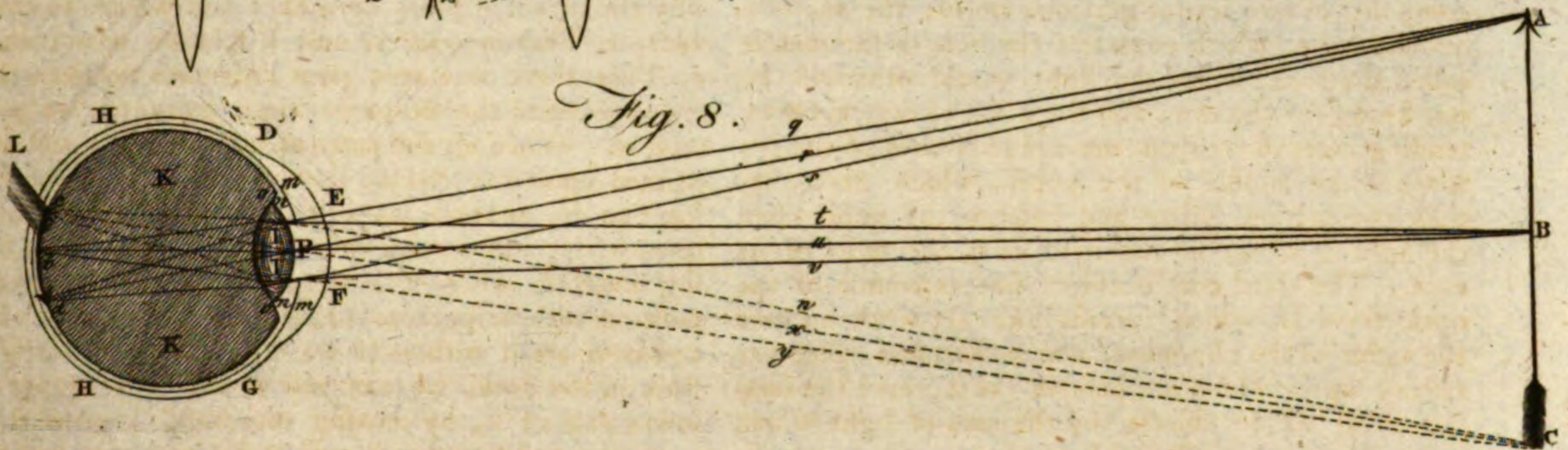
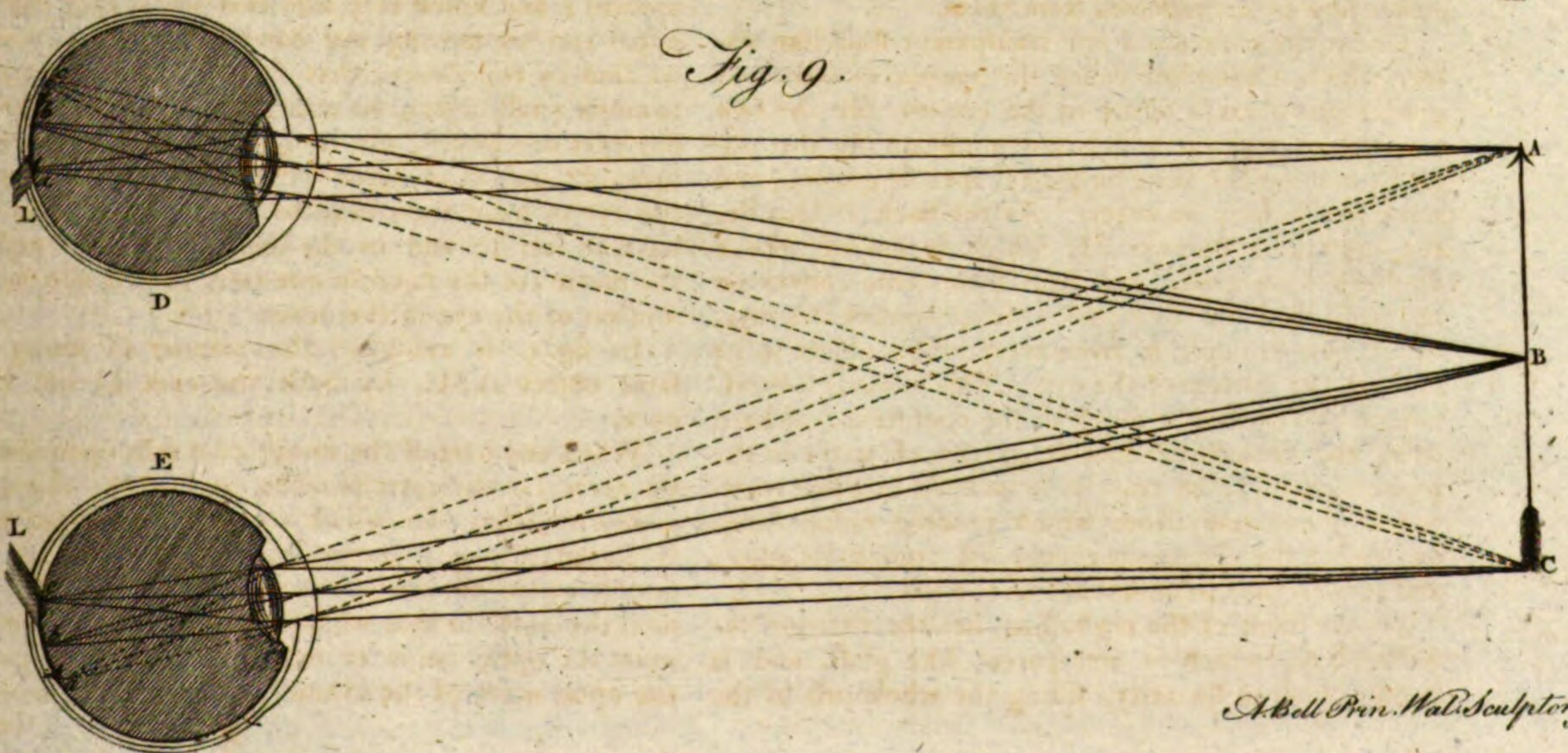
In fig. 9. is exhibited the manner of seeing the same object ABC, by both the eyes D and E at once.

When any part of the image *cba* falls upon the optic nerve L, the corresponding part of the object becomes invisible. On which account, nature has wisely placed the optic nerve of each eye, not in the middle of the bottom of the eye, but towards the side next the nose; so that whatever part of the image falls upon the optic nerve of one eye, may not fall upon the optic nerve of the other. Thus the point *a* of the image

Of Vision.
146
The objects
on the reti-
na of the
eye are in-
verted.

147
Why they
are seen up-
right.

148
An object
when view-
ed with
both eyes
does not ap-
pear double,
because the
optic nerve
is insensible
of light.

Fig. 1.*Fig. 2.**Fig. 3.**Fig. 4.**Fig. 5.**Fig. 6.**Fig. 7.**Fig. 8.**Fig. 9.*

Of Vision. image *cba* falls upon the optic nerve of the eye D, but not of the eye E; and the point *c* falls upon the optic nerve of the eye E, but not of the eye D: and therefore, to both eyes taken together, the whole object ABC is visible.

The nearer that any object is to the eye, the larger is the angle under which it is seen, and the magnitude under which it appears. Thus to the eye D, (fig. 1.) the object ABC is seen under the angle APC; and its image *cba* is very large upon the retina: but to the eye E, at a double distance, the same object is seen under the angle *ApC*, which is equal only to half the angle APC, as is evident by the figure. The image *cba* is likewise twice as large in the eye D, as the other image *cba* is in the eye E. In both these representations, a part of the image falls on the optic nerve, and the object in the corresponding part is invisible.

As the sense of seeing is allowed to be occasioned by the impulse of the rays from the visible object upon the retina of the eye, and forming the image of the object thereon, and that the retina is only the expansion of the optic nerve all over the choroides; it should seem surprising, that the part of the image which falls on the optic nerve should render the like part of the object invisible; especially as that nerve is allowed to be the instrument by which the impulse and image are conveyed to the common sensory in the brain.

149
Proved by
experiment.

That the part of the image which falls upon the middle of the optic nerve is lost, and consequently the corresponding part of the object is rendered invisible, is plain by experiment. For if a person fixes three patches, A, B, C, (fig. 2.) upon a white wall, at the height of the eye, and at the distance of about a foot from each other, and places himself before them, shutting the right eye, and directing the left towards the patch C, he will see the patches A and C, but the middle patch B will disappear. Or, if he shuts his left eye, and directs the right towards A, he will see both A and C, but B will disappear; and if he directs his eye towards B, he will see both B and A, but not C. For whatever patch is directly opposite to the optic nerve N, vanishes. This requires a little practice; after which he will find it easy to direct his eye so as to lose the sight of whichever patch he pleases.

150
Dispute
concerning
the seat of
vision.

This experiment, first tried by M. Marriotte, occasioned a new hypothesis concerning the seat of vision, which he supposed not to be in the retina, but in the choroides. An improvement was afterwards made upon it by M. Picard, who contrived that an object should disappear when both the eyes were kept open. He fastened upon a wall a round white paper, an inch or two in diameter; and by the side of it he fixed two marks, one on the right hand, and the other on the left, each at about 2 feet distance from the paper, and somewhat higher. He then placed himself directly before the paper, at the distance of 9 or 10 feet, and putting the end of his finger over against both his eyes, so that the left-hand mark might be hid from the right eye, and the right-hand mark from the left eye. Remaining firm in this posture, and looking steadily, with both eyes, on the end of his finger, the paper which was not at all covered by it would totally disappear. This, he says, is the more surprising,

Of Vision. because, without this particular encounter of the optic nerves, where no vision is made, the paper will appear double, as is the case when the finger is not rightly placed.

M. Marriotte observes, that this improvement on his experiment, by M. Picard, is ingenious, but difficult to execute, since the eyes must be considerably strained in looking at any object so near to them as four inches; and proposes another not less surprising, and more easy. Place, says he, on a dark ground, two round pieces of white paper, at the same height, and three feet from one another; then place yourself opposite to them, at the distance of 12 or 13 feet, and hold your thumb before your eyes, at the distance of about eight inches, so that it may conceal from the right eye the paper that is to the left hand, and from the left eye the paper to the right hand. Then, if you look at your thumb steadily with both eyes, you will lose sight of both the papers; the eyes being so disposed, that each of them receives the image of one of the papers upon the base of the optic nerve, while the other is intercepted by the thumb.

M. Le Cat pursued this curious experiment a little farther than M. Marriotte had done. In the place of the second paper, he fixed a large white board, and observed, that at a proper distance he lost sight of a circular space in the centre of it. He also observed the size of the paper which is thus concealed from the sight, corresponding to several distances, which enabled him to ascertain several circumstances relating to this part of the structure of the eye more exactly than had been done before.

The manner in which this curious experiment is now generally made, and which is both the easiest with respect to the eye, and the most indisputable with respect to the fact, is the following. Let three pieces of paper be fastened upon the side of a room, about two feet asunder; and let a person place himself opposite to the middle paper, and, beginning near to it, retire gradually backwards, all the while keeping one of his eyes shut, and the other turned obliquely towards that outside paper which is towards the covered eye, and he will find a situation (which is generally at about five times the distance at which the papers are placed from one another), where the middle paper will entirely disappear, while the two outermost continue plainly visible; because the rays which come from the middle paper will fall upon the retina where the optic nerve is inserted.

It will not surprise any person, even those who are the strongest advocates for the retina being the place at which the pencils of rays are terminated, and consequently the proper seat of vision, that M. Marriotte was led by this remarkable observation to suspect the contrary. He not only did so; but, in consequence of attentively considering the subject, a variety of other arguments in favour of the choroides occurred to him, particularly his observation, that the retina is transparent, as well as the crystalline and other humours of the eye, which he thought could only enable it to transmit the rays farther; and he could not persuade himself that any substance could be considered as being the termination of the pencils, and the proper seat of vision, at which the rays are not stopped in their progress.

He was farther confirmed in his opinion of the small degree

Of Vision. degree of sensibility in the retina, and of the greater sensibility of the choroides, by observing that the pupil dilates itself in the shade, and contracts itself in a great light; which involuntary motion, he thought, was a clear proof that the fibres of the iris are extremely sensible to the action of light; and this part of the eye is only a continuation of the choroides. He also thought that the dark colour of the choroides was intended to make it more susceptible of the impression of light.

M. Pecquet, in answer to M. Marriotte's observation concerning the transparency of the retina, says, that it is very imperfectly so, resembling only oiled paper, or the horn that is used for lanterns; and besides, that its whiteness demonstrates it to be sufficiently opaque for stopping the rays of light, as much as is necessary for the purpose of vision; whereas, if vision be performed by means of those rays which are transmitted through such a substance as the retina, it must be very indistinct.

As to the blackness of the choroides, which M. Marriotte thought to be necessary for the purpose of vision, M. Pecquet observes, that it is not the same in all eyes, and that there are very different shades of it among the individuals of mankind, as also among birds, and some other animals, whose choroides is generally black; and that in the eyes of lions, camels, bears, oxen, stags, sheep, dogs, cats, and many other animals, that part of the choroides which is the most exposed to light, very often exhibits colours as vivid as those of mother-of-pearl, or of the iris (F). He admits that there is a defect of vision at the insertion of the optic nerve; but he thought that it was owing to the blood-vessels of the retina, the trunks of which are so large in that place as to obstruct all vision.

To M. Pecquet's objection, founded on the opacity of the retina, M. Marriotte observes, that there must be a great difference betwixt the state of that substance in living and dead subjects; and as a farther proof of the transparency of the retina, and the power of the choroides beyond it to reflect light, he says, that if a lighted candle be held near to a person's eyes, and a dog, at the distance of eight or ten steps, be made to look at him, he would see a bright light in the dog's eyes, which he thought to proceed from the reflection of the light of the candle from the choroides of the dog, since the same appearance cannot be produced in the eyes of men, or other animals, whose choroides is black.

To M. Pecquet's remark concerning the blood vessels of the retina, M. Marriotte observes, that they are not large enough to prevent vision in every part of the base of the nerve, since the diameter of each of the two vessels occupy no more than $\frac{1}{8}$ th part of it. Besides, if this were the cause of this want of vision, it would vanish gradually, and the space to which it is confined would not be so exactly terminated as it appears to be.

Of Vision. We must add, that M. Pecquet also observed, that notwithstanding the insensibility of the retina at the insertion of the optic nerve when the light is only moderate; yet that luminous objects, such as a bright candle placed at the distance of four or five paces, do not absolutely disappear, in the same circumstances in which a white paper would; for that this strong light may be perceived though the picture fall on the base of the nerve. "I cannot help suspecting, however, (says Dr Priestley), that M. Pecquet did not make this observation with sufficient care. A large candle makes no impression on that part of my eye, though it is by no means able to bear a strong light."

The common opinion was also favoured by the anatomical description of several animals by the members of the French academy, and particularly their account of the sea-calf and porcupine; in both of which the optic nerve is inserted in the very axis of the eye, exactly opposite to the pupil, which was thought to leave no room to doubt, but that in these animals the retina is perfectly sensible to the impression of light at the insertion of the nerve. But this observation may deserve to be reconsidered.

M. De la Hire took part with M. Pecquet, arguing in favour of the retina from the analogy of the senses, in all of which the nerves are the proper seat of sensation. This philosopher, however, supposed that the choroides receives the impressions of images, in order to transmit them to the retina.

M. Perrault also took the part of M. Pecquet against M. Marriotte, and in M. Perrault's works we have several letters that passed between these two gentlemen upon this subject.

This dispute about the immediate instrument of vision was revived upon the occasion of an odd experiment of M. Mery, recorded in the memoirs of the French academy for 1704. He plunged a cat in water, and exposing her eye to the strong light of the sun, observed that the pupil was not at all contracted by it; from which he concluded, that the contraction of the iris is not produced by the action of the light, but by some other circumstance. For he contended that the eye receives more light in this situation than in the open air. At the same time he thought he observed that the retina of the cat's eye was transparent, and that he could see the opaque choroides beyond it: from which he concludes, that the choroides is the substance intended to receive the rays of light, and to be the chief instrument of vision. But M. De la Hire replies to this argument of M. Mery, in a memoir for the year 1709, p. 119; in which he endeavours to show that fewer rays enter the eye under water, and that in those circumstances it is not so liable to be affected by them. Besides, it is obvious to be remarked, that the cat must be in great terror in this situation; and being an animal that has a very great voluntary power over the muscles of the iris, and being now extremely attentive to every thing about her, she might keep her eye open notwithstanding

(F) M. Muffchenbroeck says, that in many animals, as the lion, camel, bear, ox, stag, sheep, dog, cat, and many birds, the choroides is not black, but blue, green, yellow, or some other colour. *Introductio*, Vol. II. p. 748.

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standing the action of the light upon it, and though it might be very painful to her. We are informed, that when a cat is placed in a window through which the sun is shining, and consequently her iris nearly closed, if she hear a rustling, like that which is made by a mouse, on the outside of the window, she will immediately open her eyes to their greatest extent, without in the least turning her face from the light.

M. Le Cat took part with M. Marriotte in this controversy, it being peculiarly agreeable to his general hypothesis, viz. that the pia mater, of which the choroides is a production, and not the nerves themselves, is the proper instrument of sensation. He thought that the change which takes place in the eyes of old people (the choroides growing less black with age) favoured his hypothesis, as they do not see with that distinctness with which young persons do. M. Le Cat supposed that the retina answers a purpose similar to that of the scarf-skin, covering the papillæ pyramidales, which are the immediate organ of feeling, or that of the porous membrane which covers the glandulous papillæ of the tongue. The retina, he says, receives the impression of light, moderates it, and prepares it for its proper organ, but is not itself sensible of it.

It must be observed, that M. Le Cat had discovered that the pia mater, after closely embracing and constringing the optic nerve at its entrance into the eye, divides into two branches, one of which closely lines the cornea, and at length is lost in it, while the second branch makes what is called the *choroides*, or *uvea*. He also showed that the sclerotica is an expansion of the dura mater; and he sent dissections of the eye to the royal Academy of Sciences in 1739, to prove these assertions, and several others which he had advanced in his *Traité de Sens*, that were contrary to the opinions of the celebrated Winslow.

To these arguments in favour of the choroides, alleged by those gentlemen among whom the subject was first discussed, Dr Priestley in his history adds the following that had escaped their notice, but which were suggested to him by his friend Mr Michell.

In order that vision be distinct, the pencils of rays which issue from the several points of any object, must be collected either accurately, or at least very nearly, to corresponding points in the eye, which can only be done upon some uniform surface. But the retina being of a considerable thickness, and the whole of it being uniformly nervous, and at least nearly, if not perfectly, transparent, presents no particular surface; so that, in whatever part of it the pencils be supposed to have their foci, the rays belonging to them will be separated from one another, either before or after they arrive there, and consequently vision would be confused.

If we suppose the seat of vision to be at the nearer surface of the retina, and the images of objects to be formed by direct rays, a considerable degree of confusion could not but arise from the light reflected by the choroides, in those animals in which it is white, or coloured. On the other hand, it would be impossible that vision should be performed at this place by light reflected from the choroides, because in many animals it is perfectly black, and reflects no light at all; and yet such animals see even more distinctly than others. And we cannot but suppose that, in whatever manner vi-

sion is effected, it is the same in the eyes of all animals.

If the seat of vision be at the farther surface of the retina, and it be performed by direct rays, a white choroides could be of no use; and if it were by reflected rays, a black one could not answer the purpose.

It is likewise an argument in favour of the choroides being the organ of vision, that it is a substance which receives a more distinct impression from the rays of light than any other membrane in any part of the animal system, excepting (and perhaps not excepting) that white cuticle which lies under the scales of fishes; whereas the retina is a substance on which the light makes an exceedingly faint impression, and perhaps no impression at all; since light, in passing out of one transparent medium into another immediately contiguous to it, suffers no refraction or reflection, nor are any of the rays absorbed, unless there is some difference in the refracting power of the two media, which probably is not the case between the retina and the vitreous humour, which is in contact with it. And wherever the light is not affected by the medium it falls upon, we can hardly suppose the medium to receive any impression from the light, the action being probably always mutual and reciprocal.

Besides, the retina is so situated, as to be exposed to many rays besides those which terminate in it, and which, therefore, cannot be subservient to vision, if it be performed there. Now this is not the case with the choroides, which is in no shape transparent, and has no reflecting substance beyond it.

It is, moreover, peculiarly favourable to the hypothesis of the seat of vision being in the choroides, that we can then see a sufficient reason for the diversity of its colour in different animals, according as they are circumstanced with respect to vision. In all terrestrial animals, which have occasion to make use of their eyes by night, the choroides is either of a bright white, or of some very vivid colour, which reflects the light very strongly. On this account vision may be performed with less light, but it cannot be with great distinctness, the reflection of the rays doubling their effect, since it must extend over some space, all reflection being made at a distance from the reflecting body. Besides, the choroides in brutes is not in general perfectly white, but a little inclined to blue; and is therefore, probably, better adapted to see by the fainter coloured light, which chiefly prevails in the night; and we would add, is on the same account more liable to be strongly impressed by the colours to which they are chiefly exposed.

On the other hand, the choroides of birds in general, especially eagles, hawks, and other birds of prey, is black; by which means they are able to see with the greatest distinctness, but only in bright day-light. The owl, however, seeking her food by night, has the choroides white, like that of a cat. Lastly, in the eyes of man, which are adapted to various uses, the choroides is neither so black as that of birds, nor so white as that of those animals who make the greatest use of their eyes in the night.

As to a third hypothesis, which is in effect that of M. De la Hire, which makes both the retina and the choroides equally necessary to vision, and supposes it to be performed by the impression of light on the choroides.

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communicated to the retina; Mr Michell observes, that the perceptions can hardly be supposed to be so acute, when the nerves, which are the chief instruments of sensation, do not receive the impressions immediately, but only after they have been communicated to another substance. Besides, it must be more natural to suppose, that, when the principal impression is made upon the choroides, it is communicated to the brain by its own proper nerves, which are abundantly sufficient for the purpose.

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Dimensions
of the spot
in the eye
where
there is no
vision.

Pate
CCCLVIII

The dimensions and precise form of the spot in the eye in which there is no vision, were more accurately calculated by Daniel Bernouilli, in the following manner. He placed a piece of money O (fig. 3.) upon the floor; and then shutting one of his eyes, and making a pendulum to swing, so that the extremity of it might be nearly in the line AO, he observed at what place C it began to be invisible, and where it again emerged into view at A. Raising the pendulum higher and lower, he found other points, as H, N, P, G, B, at which it began to be invisible; and others, as M, L, E, A, at which it began to be visible again; and drawing a curve through them, he found that it was elliptical; and, with respect to his own eye, the dimensions of it were as follows; OC was 23, AC 10, BD 3, DH 13, and EG 14; so that the centre being at F, the greater axis was to the less as 8 to 7.

From these data, the plane on which the figure was drawn being obliquely situated with respect to the eye, he found, that the place in the eye that corresponded to it was a circle, the diameter of which was a seventh part of the diameter of the eye, the centre of it being 27 parts of the diameter from the point opposite to the pupil, a little above the middle. He concludes with observing, that, in order that this space in which there is no vision may be as small as possible, it is necessary that the nerve should enter the eye perpendicularly, and that both this end, and also its entering the eye at a distance from its axis, are gained by the particular manner in which the two optic nerves unite and become separate again, by crossing one another.

In favour of one of the observations of Mr Michell, concerning the use of the choroides in vision, Dr Priestley observes, that Aquapendente mentions the case of a person at Pisa, who could see very well in the night, but very little or none at all in the day-time. This is also said to be the case with those white people among the blacks of Africa, and the inhabitants of the isthmus of America, who, from this circumstance, are called *moon-eyed*. Our author thinks it probable that their choroides is not of a dark colour, as it is in others of the human species; but white or light-coloured, as in those animals which have most occasion for their eyes in the night. See ALBINOS.

The following considerations in favour of the retina being the proper seat of vision, are worthy of remark.

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Arguments
for the reti-
na's being
the seat of
vision.

Dr Porterfield observes, that the reason why there is no vision at the entrance of the optic nerve into the eye, may be, that it wants that softness and delicacy which it has when it is expanded upon the choroides; and that, in those animals in which that nerve is inserted in the axis of the eye, it is observed to be equally delicate, and therefore probably equally sensible, in that place as in any other part of the retina.

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In general, the nerves, when constricted by their coats, have but little sensibility in comparison of what they are endued with when they are divested of them, and unfolded in a soft and pulpy substance.

Haller observes, that the choroides cannot be the universal instrument of vision, because that sometimes in men and birds, but especially in fishes, it is covered internally with a black mucus, through which the rays cannot penetrate. This writer speaks of a fibrous membrane in the retina distinct from its pulpy substance. On these fibres, he conjectures, that the images of objects are painted.

M. De la Hire's argument in favour of the retina, from the analogy of the senses, is much strengthened by considering that the retina is a large nervous apparatus, immediately exposed to the impression of light; whereas the choroides receives but a slender supply of nerves, in common with the sclerotica, the conjunctiva, and the eyelids, and that its nerves are much less exposed to the light than the naked fibres of the optic nerve. Indeed, from anatomical considerations, one might imagine that any other part of the body was as sensible of the impression of light as the choroides.

That the optic nerve is of principal use in vision, is farther probable from several phenomena attending some of the diseases in which the sight is affected. When an amaurosis has affected one eye only, the optic nerve of that eye has been found manifestly altered from its sound state. Dr Priestley was present when Mr Hey examined the brain of a young girl, who had been blind of one eye, and saw that the optic nerve belonging to it was considerably smaller than the other; and he informed him, that upon cutting into it, he found it to be much harder, and cineritious. Morgagni, indeed, mentions two cases, in one of which he found the optic nerves smaller than usual, and of a cineritious colour, when, upon inquiry, he was informed that the person had not been blind, though there might have been some defect in the sight of one of the eyes. In the other case, only one of the optic nerves was affected in that manner, and the eye itself was in other respects very perfect. Here, also, he was expressly told, that the person was not blind of that eye: but it appears that he himself had not been acquainted with the persons whom he dissected; and there have been many cases of persons being blind of one eye, without knowing it themselves, for a considerable time.

Moreover, as the optic nerve is solely spent in forming the retina, so no function of the eye, not immediately subservient to vision, is affected by an amaurosis. On the contrary, those nerves which go to the choroides are found to retain, in this disease, their natural influence. The iris will contract in a recent gutta serena of one eye, if the other remains sound, and is suddenly exposed to a strong light. The sclerotis, conjunctiva, and eyelids, which receive their nerves from the same branches as the choroides, retain their sensibility in this disorder.

The manner in which persons recover from an amaurosis, favours the supposition of the seat of vision being in the retina; since those parts which are the most distant from the insertion of the nerve recover their sensibility the soonest, being in those places the

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most

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most pulpy and softest; whereas there is no reason to think that there is any difference in this respect in the different parts of the choroides. Mr Hey has been repeatedly informed, by persons labouring under an imperfect amaurosis, or gutta serena, that they could not, when looking at any object with one eye, see it so distinctly when it was placed directly opposite to the pupil, as when it was situated somewhat obliquely. And those persons whom he had known to recover from a perfect amaurosis, first discovered the objects whose images fell upon that part of the retina which is at the greatest distance from the optic nerve.

We shall conclude these remarks with observing, that if the retina be as transparent as it is generally represented to be, so that the termination of the pencils must necessarily be either upon the choroides, or some other opaque substance interposed between it and the retina, the action and reaction occasioned by the rays of light being at the common surface of this body and the retina, both these mediums (supposing them to be equally sensible to the impression of light) may be equally affected; but the retina, being naturally much more sensible to this kind of impression, may be the only instrument by which the sensation is conveyed to the brain, though the choroides, or the black substance with which it is sometimes lined, may also be absolutely necessary for the purpose of vision. Indeed, when the reflection of the light is made at the common boundary of any two mediums, it is with no propriety that this effect is ascribed to one of them rather than the other; and the strongest reflections are often made back into the densest mediums, when they have been contiguous to the rarest, or even to a vacuum. This is not far from the hypothesis of M. de la Hire, and will completely account for the entire defect of vision at the insertion of the optic nerve.

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Of bright
and obscure
vision.

Vision is distinguished into *bright* and *obscure*, *distinct* and *confused*.—It is said to be bright, when a sufficient number of rays enter the pupil at the same time; obscure, when too few. It is distinct when each pencil of rays is collected into a focus exactly upon the retina; *confused*, when they meet before they come at it, or when they would pass it before they meet; for, in either of these last cases, the rays flowing from different parts of the object will fall upon the same part of the retina, which must necessarily render the image confused and indistinct.—Now, that objects may appear with a due brightness, whether more or fewer rays proceed from them, we have a power of contracting or dilating the pupil, by means of the muscular fibres of the iris, in order to take in more or fewer rays as occasion requires. But this power has its limits. In some animals it is much greater than in others; particularly in such as are obliged to seek their food by night as well as by day, as in cats, &c.

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Of distinct
vision at
different
distances.

That the rays may be collected into points exactly upon the retina, that is, that objects may appear distinct, whether they be nearer or farther off, *i. e.* whe-

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ther the rays proceeding from them diverge more or less, we have a power of contracting or relaxing the *ligamenta ciliaria*, and thereby altering the form of the crystalline humour, and with it the focal distance of the rays. Thus, when the object we view is far off, and the rays fall upon the pupil with a very small degree of divergency, we contract the *ligamenta ciliaria*, which, being concave towards the vitreous humour, do thereby compress it more than otherwise they would do: by this means it is made to press harder upon the backside of the crystalline humour, which is thereby rendered flatter; and thus the rays proceed farther before they meet in a focus, than otherwise they would have done. Add to this, that we dilate the pupils of our eyes (unless in cases where the light is so strong that it offends the eye), and thereby admit rays into them that are more diverging than those which would otherwise enter. And, when the rays come from an object that is very near, and therefore diverge too much to be collected into their respective foci upon the retina, by relaxing the *ligamenta ciliaria*, we give the crystalline a more convex form, by which means the rays are made to suffer a proportionably greater degree of refraction in passing through it. Some philosophers are of opinion that we do this by a power of altering the form of the eye; and others, by removing the crystalline forwards or backwards as occasion requires: but neither of these opinions is probable; for the coats of the eye are too hard, in some animals, for the first; and, as to moving the crystalline out of its place, the cavities of the eye seem to be too well filled with the other humours to admit of such removal.

Besides this, in the case above-mentioned, by contracting the pupils of our eyes, we exclude the more diverging rays, and admit only such as are more easily refracted into their respective foci (G). But vision is not distinct at all distances, for our power of contracting and relaxing the *ligamenta ciliaria* is also circumscribed within certain limits.

In those eyes where the tunica cornea is very protuberant and convex, the rays of light suffer a very considerable refraction at their entrance into the aqueous humour, and are therefore collected into a focus before they fall upon the retina, unless the object be placed very near, so that the rays which enter the eye may have a considerable degree of divergency. People that have such eyes are said to be *purblind*. Now, the nearer an object is to the eye, the greater is the image of it therein, as explained above: these people, therefore can see much smaller objects than others, as seeing much nearer ones with the same distinctness; and their sight continues good longer than that of other people, because the tunica cornea of their eyes, as they grow old, becomes plainer, for want of that redundancy of humours with which they were filled before. On the contrary, old men having the cornea of their eyes too flat for want of a sufficient quantity of the aqueous humour to fill them out, if the rays diverge

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Of short-
sighted and
long-sight-
ed people.

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too

(G) Accordingly it is observed, that if we make a small hole with the point of a needle through a piece of paper, and apply that hole close to the eye, making use of it, as it were, instead of a pupil, we shall be able to see an object distinctly through it, though the object be placed within half an inch of the eye.

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too much before they enter the eye, they cannot be brought to a focus before they reach the retina; on which account those people cannot see distinctly, unless the object be situated at a greater distance from the eye than is required for those whose eyes are of a due form. The latter require the assistance of convex glasses to make them see objects distinctly; the former of concave ones. For if either the cornea *abc* (fig. 4.), or crystalline humour *e*, or both of them, be too flat, as in the eye *A*, their focus will not be on the retina as at *A*, where it ought to be, in order to render vision distinct; but beyond the eye, as at *f*. This is remedied by placing a convex glass *gb* before the eye, which makes the rays converge sooner, and imprints the image duly on the retina at *d*. Again, if either the cornea, or crystalline humour, or both of them, be too convex, as in the eye *B*, the rays that enter it from the object *C* will be converged to a focus in the vitreous humour, as at *f*; and by diverging from thence to the retina, will form a very confused image thereon; and so, of course, the observer will have as confused a view of the object as if his eye had been too flat. This inconvenience is remedied by placing a concave glass *gb* before the eye; which glass, by causing the rays to diverge between it and the eye, lengthens the focal distance so, that if the glass be properly chosen, the rays will unite at the retina, and form a distinct image of the object upon it.

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Of the least
angle of
vision.

Such eyes as are of a due convexity, cannot see any object distinctly at less distance than six inches; and there are numberless objects too small to be seen at that distance, because they cannot appear under any sensible angle.—Concerning the least angle under which any object is visible, there was a debate between Dr Hooke and Hevelius. The former asserted, that no object could well be seen if it subtended an angle less than one minute; and, if the object be round, as a black circular spot upon a white ground, or a white circle upon a black ground, it follows, from an experiment made by Dr Smith, that this is near the truth; and from thence he calculates, that the diameter of the picture of such least visible point upon the retina is the 8000th part of an inch; which he therefore calls a *sensible point of the retina*. On the other hand, Mr Courtivron concluded from his experiments, that the smallest angle of vision was 40 seconds. According to Dr Jurin, there are cases in which a much smaller angle than one minute can be discerned by the eye; and in order to throw light upon the subject, he observes, that, in order to our perceiving the impression made by any object upon our senses, it must either be of a certain degree of force, or of a certain degree of magnitude. For this reason, a star, which appears only as a lucid point through a telescope, subtending not so much as an angle of one second, is visible to the eye; though a white or black spot, of 25 or 30 seconds, is not to be perceived. Also a line of the same breadth with the circular spot will be visible, at such a distance as the spot is not to be perceived at; because the quantity of impression from the line is much greater than from the spot; and a longer line is visible at a greater distance than a shorter one of the same breadth. He found by experience, that a silver wire could be seen when it subtended an

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Lines can
be seen un-
der smaller
angles than
spots, and
why.

angle of three seconds and an half; and that a silk thread could be seen when it subtended an angle of two seconds and an half.

This greater visibility of a line than of a spot seems to arise only from the greater quantity of the impression; but without the limits of perfect vision, our author observes, that another cause concurs, whereby the difference of visibility between the spot and the line is rendered much more considerable. For the impression upon the retina made by the line is then not only much greater, but also much stronger, than that of the spot; because the faint image, or penumbra, of any one point of the line, when the whole is placed beyond the limits of distinct vision, will fall within the faint image of the next point, and thereby much increase the light that comes from it.

In some cases our author found the cause of indistinct vision to be the unsteadiness of the eye; as our being able to see a single black line upon a white ground, or a single white line upon a black ground, and not a white line between two black ones on a white ground. In viewing either of the former objects, if the eye be imperceptibly moved, all the effect will be, that the object will be painted upon a different part of the retina; but, wherever it is painted, there will be but one picture, single and uncompounded with any other. But in viewing the other, if the eye fluctuate ever so little, the image of one or other of the black lines will be shifted to that part of the retina which was before possessed by the white line; and this must occasion such a dazzle in the eye, that the white line cannot be distinctly perceived, and distinguished from the black lines; which, by a continual fluctuation, will alternately occupy the space of the white line, whence must arise an appearance of one broad dark line, without any manifest separation.

By trying this experiment with two pins of known diameters, set in a window against the sky light, with a space between them equal in breadth to one of the pins, he found that the distance between the pins could hardly be distinguished when it subtended an angle of less than 40 seconds, though one of the pins alone could be distinguished when it subtended a much less angle. But though a space between two pins cannot be distinguished by the eye when it subtends an angle less than 40 seconds, it would be a mistake to think that the eye must necessarily commit an error of 40 seconds in estimating the distance between two pins when they are much farther from one another. For if the space between them subtend an angle of one minute, and each of the pins subtend an angle of four seconds, which is greater than the least angle the eye can distinguish, it is manifest that the eye may judge of the place of each pin within two seconds at the most; and consequently the error committed in taking the angle between them cannot at the most exceed four seconds, provided the instrument be sufficiently exact. And yet, says he, upon the like mistake was founded the principal objection of Dr Hooke against the accuracy of the celestial observations of Hevelius.

A black spot upon a white ground, or a white spot upon a black ground, he says, can hardly be perceived by the generality of eyes when it subtends a less angle than one minute. And if two black spots be made

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upon white paper, with a space between them equal in breadth to one of their diameters, that space is not to be distinguished, even within the limits of perfect vision, under so small an angle as a single spot of the same size can be distinguished. To see the two spots distinctly, therefore, the breadth of the space between them must subtend an angle of more than a minute. It would be very difficult, he says, to make this experiment accurately, within the limits of perfect vision; because the objects must be extremely small: but by a rude trial, made with square bits of white paper, placed upon a black ground, he judged, that the least angle under which the interval of two objects could be perceived, was at least a fourth part greater than the least angle under which a single object can be perceived. So that an eye which cannot perceive a single object under a smaller angle than one minute, will not perceive the interval between two such objects under a less angle than 75 seconds.

Without the limits of perfect vision, the distance at which a single object ceases to be perceivable will be much greater in proportion than the distance at which a space of equal breadth between two such objects ceases to be perceivable. For, without these limits, the image of each of the objects will be attended with a penumbra, and the penumbra of the two near objects will take up part of the space between them, and thereby render it less perceivable; but the penumbra will add to the breadth of the single object, and will thereby make it more perceivable, unless its image be very faint. Upon the same principles he likewise accounts for the radiation of the stars, whereby the light seems to project from them different ways at the same time.

Mr Mayer made many experiments in order to ascertain the smallest angle of vision in a variety of respects. He began with observing at what distance a black spot was visible on white paper; and found, that when it could barely be distinguished, it subtended an angle of about 34 seconds. When black lines were disposed with intervals broader than themselves, they were distinguished at a greater distance than they could be when the objects and the intervals were of an equal breadth. In all these cases it made no difference whether the objects were placed in the shade or in the strong light of the sun; but when the degrees of light were small, their differences had a considerable effect, though by no means in proportion to the differences of the light. For if an object was illuminated to such a degree as to be just visible at the distance of nine feet, it would be visible at the distance of four feet, though the light was diminished above 160 times. It appeared in the course of these experiments, that common day light is, at a medium, equal to that of 25 candles placed at the distance of one foot from the object.

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Of single
vision with
two eyes.

As an image of every visible object is painted on the retina of each of our eyes, it thence becomes a natural question, Why we do not see every thing double? It was the opinion of Sir Isaac Newton and others, that objects appear single because the two optic nerves unite before they reach the brain. But Dr Porterfield shows, from the observation of several anatomists, that the optic nerves do not mix, or confound their substance, being only united by a close cohesion; and ob-

jects have appeared single where the optic nerves were found to be disjointed.

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Dr Briggs supposed that single vision was owing to the equal tension of the corresponding parts of the optic nerves, whereby they vibrated in a synchronous manner. But, besides several improbable circumstances in this account, Dr Porterfield shows that facts do by no means favour it.

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Solutions of
this diffi-
culty by
Dr Briggs.

To account for this phenomenon, this ingenious writer supposes, that by an original law in our natures, we imagine objects to be situated somewhere in a right line drawn from the picture of it upon the retina, through the centre of the pupil. Consequently, the same object appearing to both eyes to be in the same place, the mind cannot distinguish it into two. In answer to an objection to this hypothesis, from objects appearing double when one eye is distorted, he says the mind mistakes the position of the eye, imagining that it had moved in a manner corresponding to the other, in which case the conclusion would have been just. In this he seems to have recourse to the power of habit, though in words he disclaims that hypothesis.

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Dr Porter-
field,

This principle, however, has generally been thought to be sufficient to account for this appearance. Originally, every object making two pictures, one in each eye, is imagined to be double; but by degrees, we find, that when two corresponding parts of the retina are impressed, the object is but one; but if those corresponding parts be changed, by the distortion of one of the eyes, the object must again appear double as at the first. This seems to be verified by Mr Cheselden; who informs us, that a gentleman, who from a blow on his head had one eye distorted, found every object to appear double; but by degrees the most familiar ones came to appear single again, and in time all objects did so, without any amendment of the distortion. A case similar to this is mentioned by Dr Smith.

On the other hand, Dr Reid is of opinion, that the correspondence of the centres of the two eyes, on which single vision depends, does not arise from custom, but from some natural constitution of the eye and of the mind. He makes several just objections to the case of Mr Foster, recited by Dr Smith and others; and thinks that the case of the young man couched by Cheselden, who saw singly with both eyes immediately upon receiving his sight, is nearly decisive in proof of his supposition. He also found that three young gentlemen, whom he endeavoured to cure of squinting, saw objects singly, as soon as ever they were brought to direct the centres of both their eyes to the same object, though they had never been used to do so from their infancy; and he observes, that there are cases, in which, notwithstanding the fullest conviction of an object being single, no practice of looking at it will ever make it appear so, as when it is seen through a multiplying glass.

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Dr Reid,
and

To all these solutions of the difficulty respecting single vision by both eyes, objections have been lately made which seem insurmountable. By experiments judiciously conceived and accurately conducted, Dr Wells has shown, that it is neither by custom alone, nor by an original property of the eyes alone, that objects appear single; and having demolished the theories

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of others, he thus accounts for the phenomenon himself.

"The visible place of an object being composed of its visible distance and visible direction, to show how it may appear the same to both eyes, it will be necessary (says he*) to explain in what manner the distance and direction, which are perceived by one eye, may coincide with those which are perceived by the other." With respect to visible distance, the author's opinion seems not to differ from that which we have stated elsewhere (see METAPHYSICS, n^o 49, 50); and therefore we have to attend only to what he says of visible direction.

When a small object is so placed with respect to either eye, as to be seen more distinctly than in any other situation, our author says that it is then in the *optic axis*, or the axis of that eye. When the two optic axes are directed to a small object not very distant, they may be conceived to form two sides of a triangle, of which the base is the interval between the points of the corners where the axes enter the eyes. This base he called the *visual base*; and a line drawn from the middle of it to the point of intersection of the optic axes he calls the *common axis*. He then proceeds to show, that objects *really situated* in the *optic axis* do not *appear* to be in that line, but in the *common axis*.

"Every person (says he) knows, that if an object be viewed through two small holes, one applied to each eye, the two holes appear but as one. The theories hitherto invented afford two explanations of this fact. According to Aguilonius, Dechales, Dr Porterfield, and Dr Smith, the two holes, or rather their borders, will be seen in the same place as the object viewed through them, and will consequently appear united, for the same reason that the object itself is seen single. But whoever makes the experiment will distinctly perceive, that the united hole is much nearer to him than the object; not to mention, that any fallacy on this head might be corrected by the information from the sense of touch, that the card or other substance in which the holes have been made is within an inch or less of our face. The other explanation is that furnished by the theory of Dr Reid. According to it, the centres of the retinas, which in this experiment receive the pictures of the holes, will, by an original property, represent but one. This theory, however, though it makes the two holes to appear one, does not determine where this one is to be seen. It cannot be seen in only one of the perpendiculars to the images upon the retinas, for no reason can be given why this law of visible direction, which Dr Reid thinks established beyond dispute, if it operates at all, should not operate upon both eyes at the same time; and if it be seen by both eyes in such lines, it must appear where those lines cross each other, that is, in the same place with the object viewed through the holes, which, as I have already mentioned, is contrary to experience. Nor is it seen in any direction, the consequence of a law affecting both eyes considered as one organ, but suspended when each eye is used separately. For when the two holes appear one, if we pay attention to its situation, and then close one eye, the truly single hole will be seen by the eye remaining open in exactly the same direction as the apparently single hole was by both eyes.

"Hitherto I have supposed the holes almost touching the face. But they have the same unity of appearance, in whatever parts of the optic axes they are placed; whether both be at the same distance from the eyes, or one be close to the eye in the axis of which it is, and the other almost contiguous to the object seen through them. If a line, therefore, be drawn from the object to one of the eyes, it will represent all the real or tangible positions of the hole, which allow the object to be seen by that eye, and the whole of it will coincide with the optic axis. Let a similar line be drawn to the other eye, and the two must appear but as one line; for if they do not, the two holes in the optic axes will not, at every distance, appear one, whereas experiments prove that they do. This united line will therefore represent the visible direction of every object situated in either of the optic axes. But the end of it, which is toward the face, is seen by the right eye to the left, and by the left eye as much to the right. It must be seen then in the middle between the two, and consequently in the common axis. And as its other extremity coincides with the point where the optic axes intersect each other, the whole of it must lie in the common axis. Hence the truth of the proposition is evident, that objects situated in the optic axis, do not appear to be in that line, but in the common axis."

He then proves by experiments, for which we must refer to his work, that objects situated in the common axis do not *appear* to be in that line, but in the axis of the eye by which they are not seen: that is, an object situated in the common axis appears to the right eye in the axis of the left, and *vice versa*. His next proposition, proved likewise by experiments, is, that "objects, situated in any line drawn through the mutual intersection of the optic axes to the visual base, do not appear to be in that line, but in another, drawn through the same intersection, to a point in the visual base distant half this base from the similar extremity of the former line towards the left, if the objects be seen by the right eye, but towards the right if seen by the left eye."

From these propositions he thus satisfactorily accounts for single vision by both eyes. "If the question be concerning an object at the concurrence of the optic axes, it is seen single, because its two similar appearances, in regard to size, shape, and colour, are seen by both eyes in one and the same direction, or, if you will, in two directions, which coincide with each other through the whole of their extent. It therefore matters not whether the distance be truly or falsely estimated; whether the object be thought to touch our eyes, or to be infinitely remote. And hence we have a reason, which no other theory of visible direction affords, why objects appeared single to the young gentleman mentioned by Mr Cheselden, immediately after his being couched, and before he could have learned to judge of distance by sight.

"When two similar objects are placed in the optic axes, one in each, at equal distances from the eyes, they will appear in the same place, and therefore one, for the same reason that a truly single object, in the concurrence of the optic axes, is seen single.

"To finish this part of my subject, it seems only necessary to determine, whether the dependence of visible direction upon the actions of the muscles of the

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eyes be established by nature, or by custom. But facts are here wanting. As far as they go, however, they serve to prove that it arises from an original principle of our constitution. For Mr Cheselden's patient saw objects single, and consequently in the same directions with both eyes, immediately after he was couched; and persons affected with squinting from their earliest infancy see objects in the same directions with the eye they have never been accustomed to employ, as they do with the other they have constantly used."

The author removes many difficulties, and obviates the objections to which his theory may seem most liable. The whole work deserves to be attentively studied by every optician; and we therefore recommend it to the perusal of our readers.

We are indebted to Dr Jurin for the following curious experiments, to determine whether an object seen by both eyes appears brighter than when seen with one only.

He laid a slip of clean white paper directly before him on a table, and applying the side of a book close to his right temple, so as that the book was advanced considerably more forward than his face, he held it in such a manner, as to hide from his right eye that half of the paper which lay to his left hand, while the left half of the paper was seen by both eyes, without any impediment.

Then looking at the paper with both eyes, he observed it to be divided, from the top to the bottom, by a dark line, and the part which was seen with one eye only was manifestly darker than that which was seen with both eyes; and, applying the book to his left temple, he found, by the result of the experiment, that both his eyes were of equal goodness.

He then endeavoured to find to what degree this excess of brightness amounted; and comparing it with the appearance of an object illuminated partly by one candle and partly by two, he was surprised to find that an object seen with two eyes is by no means twice as luminous as when it is seen with one only; and after a number of trials, by which he made the proportion less and less continually, he found, that when one paper was illuminated by a candle placed at the distance of three feet, and another paper by the same candle at the same distance, and by another candle at the distance of 11 feet, the former seen by both eyes, and the latter with one eye only, appeared to be of equal whiteness; so that an object seen with both eyes appears brighter than when it is seen with one only by about a 13th part. But he acknowledges, that it is difficult to make this experiment exactly.

He then proceeded to inquire, whether an object seen with both eyes appears any thing larger than when seen with one only; but he concluded that it did not, except on account of some particular circumstances, as in the case of the binocular telescope and the concave speculum.

M. du Tour maintains, that the mind attends to no more than the image made in one eye at a time; and produces several curious experiments in favour of this hypothesis, which had also been maintained by Kepler and almost all the first opticians. But, as M. Buffon observes, it is a sufficient answer to this hypothesis, how ingeniously soever it may be supported, that we see more distinctly with two eyes than with one; and that

when a round object is near us, we plainly see more of the surface in one case than in the other. There are also other facts which clearly prove the contrary of what is maintained by M. du Tour.

With respect to single vision with two eyes, Dr Hartley observes, that it deserves particular attention, that the optic nerves of men, and such other animals as look the same way with both eyes, unite in the *cella turcica* in a ganglion, or little brain, as one may call it, peculiar to themselves; and that the associations between synchronous impressions on the two retinas must be made sooner and cemented stronger on this account; also that they ought to have a much greater power over one another's images, than in any other part of the body. And thus an impression made on the right eye alone, by a single object, may propagate itself into the left, and there raise up an image almost equal in vividness to itself; and consequently when we see with one eye only, we may, however, have pictures in both eyes.

A curious deception in vision, arising from the use of both eyes, was observed and accounted for by Dr Smith. It is a common observation, he says, that objects seen with both eyes appear more vivid and stronger than they do to a single eye; especially when both of them are equally good. A person not short-sighted may soon be convinced of this fact, by looking attentively at objects that are pretty remote, first with one eye, and then with both. This observation gave occasion to the construction of the binocular telescope, in the use of which the phenomenon is still more striking.

Besides this, our author observes, that there is another phenomenon observable with this instrument, which is very remarkable. In the foci of the two telescopes there are two equal rings, as usual, which terminate the pictures of the objects there formed, and consequently the visible area of the objects themselves. These equal rings, by reason of the equal eye-glasses, appear equal, and equally distant when seen separately by each eye; but when they are seen with both eyes, they appear much larger, and more distant also; and the objects seen through them do also appear much larger, though circumscribed by their united rings, in the same places as when they were seen separately.

He observes, that the phenomenon of the enlarged circle of the visible area in the binocular telescope, may be seen very plainly in looking at distant objects through a pair of spectacles, removed from the eyes about four or five inches, and held steady at that distance. The two innermost of the four apparent rings, which hold the glasses, will then appear united in one larger and more distant ring than the two outermost, which will hardly be visible unless the spectacles be farther removed.

A curious circumstance relating to the effect of one eye upon the other, was noticed by M. Æpinus, who observed, that, when he was looking through a hole made in a plate of metal, about the 10th part of a line in diameter, with his left eye, both the hole itself appeared larger, and also the field of view seen through it was more extended, whenever he shut his right eye; and both these effects were more remarkable when that eye was covered with his hand. He found considerable difficulty in measuring this augmentation of the apparent

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apparent diameter of the hole, and of the field of view; but at length he found, that, when the hole was half an inch, and the tablet which he viewed through it was three feet from his eye, if the diameter of the field when both his eyes were open was 1, it became $1\frac{1}{2}$ when the other eye was shut, and nearly 2 when his hand was laid upon it.

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When one eye is closed, the pupil of the other is enlarged.

Upon examining this phenomenon, it presently appeared to depend upon the enlargement of the pupil of one eye when the other is closed, the physical or anatomical cause of which he did not pretend to assign; but he observes, that it is wisely appointed by divine Providence, in order that when one eye fails, the field of view in the other may be extended. That this effect should be more sensible when the eye is covered with the hand, is owing, he observes, to the eye-lids not being impervious to the light. But the enlargement of the pupil does not enlarge the field of view, except in looking through a hole, as in this particular case; and therefore persons who are blind of one eye can derive no advantage from this circumstance. Before we applaud the wisdom of Providence in any part of the constitution of nature, we should be very sure that we do not mistake concerning the effects of that constitution.

A great deal has been written by Gassendi, Le Clerc, Musschenbroek, and Du Tour, concerning the place to which we refer an object viewed by one or both eyes. But the most satisfactory account of this matter that we have met with, the reader will find in Dr Wells's Essay above quoted, which will teach any person how to satisfy himself by experiment with respect to visible position and visible motion.

§ 4. *Of the Appearance of Objects seen through Media of different Forms.*

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The various appearances of objects seen through media of different forms stated and investigated.

For the more easy apprehension of what relates to this subject, we shall premise the five following particulars, which either have been already mentioned, or follow from what has been before laid down.

1. That as each point of an object, when viewed by the naked eye, appears in its proper place, and as that place is always to be found in the line in which the axis of a pencil of rays flowing from it enters the eye, or else in the line which Dr Wells calls the common axis; we from hence acquire an habit of judging the point to be situated in that line: and, because the mind is unacquainted with what refractions the rays suffer before they enter the eye, therefore, in cases where they are diverted from their natural course, by passing through any medium, it judges the point to be in that line produced back in which the axis of a pencil of rays flowing from it is situated the instant they enter the eye, and not in that it was in before refraction. We shall therefore, in what follows, suppose the apparent place of an object, when seen thro' a refracting medium, to be somewhere in that line produced back in which the axis of a pencil of rays flowing from it proceeds after they have passed through the medium.

2. That we are able to judge, though imperfectly, of the distance of an object by the degree of divergency, wherein the rays flowing from the same point of the object enter the pupil of the eye, in cases where that divergency is considerable; but because in what

follows it will be necessary to suppose an object, when seen through a medium whereby its apparent distance is altered, to appear in some determinate situation, in those cases where the divergency of the rays at their entrance into the eye is considerable, we will suppose the object to appear where those lines which they describe in entering, if produced back, would cross each other: though it must not be asserted, that this is the precise distance; because the brightness, distinctness, and apparent magnitude of the object, on which its apparent distance in some measure depends, will also suffer an alteration by the refraction of the rays in passing through that medium.

3. That we estimate the magnitude of an object by that of the optic angle.

4. That vision is the brighter, the greater the number of rays is which enter the pupil. And,

5. That, in some cases, the apparent brightness, distinctness, and magnitude of an object, are the only means whereby our judgment is determined in estimating the distance of it.

PROP. I. An object placed within a medium terminated by a plane surface on that side which is next the eye, if the medium be denser than that in which the eye is (as we shall always suppose it to be, unless where the contrary is expressed), appears nearer to the surface of the medium than it is.

Thus, if A be a point of an object placed within the medium BDCE (fig. 5.), and Ab Ac be two rays proceeding from thence, these rays passing out of a denser into a rarer medium, will be refracted from their respective perpendiculars bd, ce, and will enter the eye at H, suppose in the directions bf, cg: let then these lines be produced back till they meet in F; this will be the apparent place of the point A: and because the refracted rays bf, cg will diverge more than the incident ones Ab, Ac, it will be nearer to the points b and c than the point A; and as the same is true of each point in the object, the whole will appear to an eye at H, nearer to the surface BC than it is.

From hence it is, that when one end of a straight stick is put under water, and the stick is held in an oblique position, it appears bent at the surface of the water; viz. because each point that is under water appears nearer the surface, and consequently higher than it is.

From hence likewise it is, that an object at the bottom of a vessel may be seen when the vessel is filled with water, though it be so placed with respect to the eye, that it cannot be seen when the vessel is empty. To explain this, let ABCD (fig. 6.) represent a vessel, and let E be an object lying at the bottom of it. This object, when the vessel is empty, will not be seen by an eye at F, because HB, the upper part of the vessel, will obstruct the ray EH; but when it is filled with water to the height GH, the ray EK being refracted at the surface of the water into the line KF, the eye at F shall see the object by means of that.

In like manner, an object situated in the horizon appears above its true place, upon account of the refraction of the rays which proceed from it in their passage through the atmosphere of the earth. For, first, if the object be situated beyond the limits of the atmosphere, its rays in entering it will be refracted towards the

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An object situated in the horizon appears above its true place.

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the perpendicular; that is, towards a line drawn from the point where they enter, to the centre of the earth, which is the centre of the atmosphere: and as they pass on, they will be continually refracted the same way, because they are all along entering a denser part, the centre of whose convexity is still the same point; upon which account the line they describe will be a curve bending downwards: and therefore none of the rays that come from that object can enter an eye upon the surface of the earth, except what enter the atmosphere higher than they need to do if they could come in a right line from the object: consequently the object must appear above its proper place. Secondly, if the object be placed within the atmosphere, the case is still the same; for the rays which flow from it must continually enter a denser medium whose centre is below the eye; and therefore being refracted towards the centre, that is, downwards as before, those which enter the eye must necessarily proceed as from some point above the object; wherefore the object will appear above its proper place.

From hence it is, that the sun, moon, and stars, appear above the horizon, when they are just below it; and higher than they ought to do, when they are above it: Likewise distant hills, trees, &c. seem to be higher than they are.

Further, the lower these objects are in the horizon, the greater is the obliquity with which the rays which flow from them enter the atmosphere, or pass from the rarer into the denser parts of it; and therefore they appear to be the more elevated by refraction: upon which account the lower parts of them are apparently more elevated than the other. This makes their upper and under parts seem nearer than they are; as is evident from the sun and moon, which appear of an oval form when they are in the horizon, their horizontal diameters appearing of the same length they would do if the rays suffered no refraction, while their vertical ones are shortened thereby.

PROP. II. An object seen through a medium terminated by plane and parallel surfaces, appears nearer, brighter, and larger, than with the naked eye.

For instance, let AB (fig. 7.) be the object, CDEF the medium, and GH the pupil of an eye, which is here drawn large to prevent confusion in the figure. And, 1st, let RK, RL, be two rays proceeding from the point R, and entering the denser medium at K and L; these rays will here by refraction be made to diverge less, and to proceed afterwards, suppose in the lines Ka, Lb; at a and b, where they pass out of the denser medium, they will be as much refracted the contrary way, proceeding in the lines ac, bd, parallel to their first directions. Produce these lines back till they meet in e: this will be the apparent place of the point R; and it is evident from the figure, that it must be nearer the eye than that point; and because the same is true of all other pencils flowing from the object AB, the whole will be seen in the situation fg, nearer to the eye than the line AB. 2d, As the rays RK, RL, would not have entered the eye, but have passed by it in the directions Kr, Lt, had they not been refracted in passing through the medium, the object appears brighter. 3d, The rays Ab, Bi, will be refracted at b and i into the less converging lines bk, il, and at the other surface into kM,

lM, parallel to Ab and Bi produced; so that the extremities of the object will appear in the lines Ml, M/ produced, viz. in f and g, and under as large an angle fMg, as the angle AgB under which an eye at g would have seen it had there been no medium interposed to refract the rays; and therefore it appears larger to the eye at GH, being seen through the interposed medium, than otherwise it would have done. But it is here to be observed, that the nearer the point e appears to the eye on account of the refraction of the rays RK, RL, the shorter is the image fg, because it is terminated by the lines Mf and Mg, upon which account the object is made to appear less; and therefore the apparent magnitude of an object is not much augmented by being seen through a medium of this form.

Farther, it is apparent from the figure, that the effect of a medium of this form depends wholly upon its thickness; for the distance between the lines Rr and ee, and consequently the distance between the points e and R, depends upon the length of the line Ka. Again, the distance between the lines AM and fM depends on the length of the line bk; but both Ka and kb depend on the distance between the surfaces CE and DF, and therefore the effect of this medium depends upon its thickness.

PROP. III. An object seen through a convex lens, appears larger, brighter, and more distant, than with the naked eye.

To illustrate this, let AB (fig. 8.) be the object, CD the lens, and EF the eye. 1. From A and B, the extremities of the object, draw the lines AYr, BXr, crossing each other in the pupil of the eye; the angle ArB comprehended between these lines, is the angle under which the object would be seen with the naked eye. But by the interposition of a lens of this form, whose property it is to render converging rays more so, the rays AY and BX will be made to cross each other before they reach the pupil. There the eye at E will not perceive the extremities of the object by means of these rays (for they will pass it without entering), but by some others which must fall without the points Y and X, or between them; but if they fall between them, they will be made to concur sooner than they themselves would have done; and therefore, if the extremities of the object could not be seen by them, it will much less be seen by these. It remains therefore, that the rays which will enter the eye from the points A and B after refraction, must fall upon the lens without the points Y and X; let then the rays AO and BP be such. These after refraction entering the eye at r, the extremities of the object will be seen in the lines rQ, rT, produced, and under the optic angle QrT, which is larger than ArB, and therefore the apparent magnitude of the object will be increased. 2. Let GHI be a pencil of rays flowing from the point G; as it is the property of this lens to render diverging rays less diverging, parallel, or converging, it is evident that some of those rays, which would proceed on to F and E, and miss the eye, were they to suffer no refraction in passing through the lens, will now enter it; by which means the object will appear brighter. 3. As to the apparent distance of the object, that will vary according to the situation of it with respect to the focus of parallel rays of the lens.

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An object
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Appear-
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through
Media of
different
Forms.

1. Then, let us suppose the object placed so much nearer the lens than its focus of parallel rays, that the refracted rays KE and LF, though rendered less diverging by passing through it, may yet have a considerable degree of divergency, so that we may be able to form a judgment of the distance of the object thereby. In this case, the object ought to appear where EK, FL, produced back concur; which, because they diverge less than the rays GH, GI, will be beyond G, that is, at a greater distance from the lens than the object is. But because both the brightness and magnitude of the object will at the same time be augmented, prejudice will not permit us to judge it quite so far off as the point where those lines meet, but somewhere between that point and its proper place.

2. Let the object be placed in the focus of parallel rays, then will the rays KE and LF become parallel; and though in this case the object would appear at an immense distance, if that distance were to be judged of by the direction of the rays KE and LF, yet upon account of the brightness and magnitude of it, we shall not think it much farther from us than if it were seen by the naked eye.

3. If the object be situated beyond the focus of parallel rays, as in BA (fig. 9.), the rays flowing from thence and falling upon the lens CD, will be collected into their respective foci at *a* and *b*, and the intermediate points *m*, *n*, &c. and will there form an image of the object AB; and after crossing each other in the several points of it, as expressed in the figure, will pass on diverging as from a real object. Now if an eye be situated at *c*, where Ac, Bc, rays proceeding from the extreme points of the object, make not a much larger angle AcB, than they would do if there were no lens interposed, and the rays belonging to the same pencil do not converge so much as those which the eye would receive if it were placed nearer to *a* or *b*, the object upon these accounts appearing very little larger or brighter than with the naked eye, is seen nearly in its proper place; but if the eye recedes a little way towards *a* or *b*, the object then appearing both brighter and larger, seems to approach the lens: which is an evident proof of what has been so often asserted, viz. that we judge of the distance of an object in some measure by its brightness and magnitude; for the rays converge the more the farther the eye recedes from the lens; and therefore if we judged of the distance of the object by the direction of the rays which flow from it, we ought in this case to conceive it at a greater distance, than when the rays were parallel, or diverged at their entrance into the eye.

That the object should seem to approach the lens in this case, was a difficulty that exceedingly puzzled the learned Barrow, and which he pronounces insuperable, and not to be accounted for by any theory we have of vision. Molineux also leaves it to the solution of others, as that which will be inexplicable, till a more intimate knowledge of the visive faculty, as he expresses it, be obtained by mortals.

They imagined, that seeing an object appears farther off, the less the rays diverge which fall upon the eye, if they should proceed parallel to each other, it ought to appear exceeding remote; and if they should converge, it should then appear more distant still: the reason of this was, because they looked upon the ap-

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parent place of an object, as owing only to the direction of the rays whatever it was, and not at all to its apparent magnitude or splendor.

Perhaps it may proceed from our judging of the distance of an object in some measure by its magnitude, that that deception of sight commonly observed by travellers may arise; viz. that upon the first appearance of a building larger than usual, as a cathedral church, or the like, it generally seems nearer to them, than they afterwards find it to be.

PROB. IV. If an object be placed farther from a convex lens than its focus of parallel rays, and the eye be situated farther from it on the other side than the place where the rays of the several pencils are collected into their respective foci, the object appears inverted, and pendulous in the air, between the eye and the lens.

To explain this, let AB (fig. 9.) represent the object, CD the lens; and let the rays of the pencil ACD be collected in *a*, and those of BCD in *b*, forming there an inverted image of the object AB, and let the eye be placed in F: it is apparent from the figure, that some of the refracted rays which pass through each point of the image will enter the eye as from a real object in that place; and therefore the object AB will appear there, as the proposition asserts. But we are so little accustomed to see objects in this manner, that it is very difficult to perceive the image with one eye; but if both eyes are situated in such a manner, that rays flowing from each point of the image may enter both, as at G and H, and we direct our optic axes to the image, it is easy to be perceived.

If the eye be situated in *a* or *b*, or very near them on either side, the object appears exceedingly confused, viz. if at *d*, the rays which proceed from the same point of the object converge so very much, and if at *e*, they diverge so much, that they cannot be collected together upon the retina, but fall upon it as if they were the axes of so many distinct pencils coming thro' every point of the lens; wherefore little more than one single point of the object is seen at a time, and that appears all over the lens; from whence nothing but confusion arises.

If the lens be so large that both eyes may be applied to it, as in *b* and *k*, the object will appear double; for it is evident from the figure, that the rays which enter the eye at *b* from either extremity of the object A or B, do not proceed as from the same point with that from whence those which enter the other at *k* seem to flow; the mind therefore is here deceived, and looks upon the object as situated in two different places, and therefore judges it to be double.

PROP. V. An object seen through a concave lens appears nearer, smaller, and less bright, than with the naked eye.

Thus, let AB (fig. 10.) be the object, CD the pupil of an eye, and EF the lens. Now, as it is the property of a lens of this form to render diverging rays more so, and converging ones less so, the diverging rays GH, GI, proceeding from the point G, will be made to diverge more, and so to enter the eye as from some nearer point *g*; and the rays AH, BI, which converge, will be made to converge less, and to enter the eye as from the points *a* and *b*; wherefore the objects will appear in the situation *agb*, less

and

Appear-
ance of Ob-
jects seen
through
Media of
different
Forms.

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In certain
circum-
stances an
object seen
through a
convex lens
appears in-
verted and
pendulous
in the air.

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An object
through a
concave
lens is seen
nearer,
smaller, and
less bright
than with
the naked
eye.

Plate
CCCLVIII.

Reflection
of Light.

and nearer than without the lens. Farther, as the rays which proceed from G are rendered more diverging, some of them will be made to pass by the pupil of the eye, which otherwise would have entered it, and therefore each point of the object will appear less bright.

PROP. VI. An object seen through a polygonous glass, that is, such as is terminated by several plain surfaces, is multiplied thereby.

Plate
CCCLV III

For instance, let A (fig. 11). be an object, and BC a polygonous glass terminated by the plain surfaces BD, DE, &c. and let the situation of the eye F be such, that the rays AB being refracted in passing through the glass, may enter it in the direction BF, and the rays AC in the direction CF. Then will the eye, by means of the former, see the object in G, and by the latter in H; and by means of the rays AI, the object will appear also in its proper situation A.

SECT. III. Of the Reflection of Light.

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Some portion of light
always re-
flected from
transparent
bodies.

WHEN a ray of light falls upon any body, however transparent, the whole of it never passes through the body, but some part is always driven back or reflected from it; and it is by this reflected light that all bodies which have no light of their own become visible to us. Of that part of the ray which enters, another part is also reflected from the second surface, or that which is farthest from the luminous body. When this part arrives again at the first surface, part of it is reflected back from that surface; and thus it continues to be reflected between the two surfaces, and to pass backwards and forwards within the substance of the medium, till some part is totally extinguished and lost. Besides this inconsiderable quantity, however, which is lost in this manner, the second surface often reflects much more than the first; insomuch that, in certain positions, scarce any rays will pass through both sides of the medium. A very considerable quantity is also unaccountably lost or extinguished at each reflecting surface; insomuch that no body, however transparent, can transmit all the rays which fall upon it; neither, tho' it be ever so well fitted for reflection, will it reflect them all.

§ 1. Of the Cause of Reflection.

THE reflection of light is by no means so easily accounted for as the refraction of the same fluid. This property, as we have seen in the last section, may be accounted for in a satisfactory manner by the supposition of an attractive power diffused throughout the medium, and extending a very little way beyond it; but with regard to the reflection of light, there seems to be no satisfactory hypothesis hitherto invented. Of the principal opinions on this subject Mr Rowning hath given us the following account.

I. It was the opinion of philosophers, before Sir Isaac Newton discovered the contrary, that light is reflected by impinging upon the solid parts of bodies. But that it is not so, is clear for the following reasons.

And first, it is not reflected at the first surface of a body by impinging against it.

For it is evident, that, in order to the due and

regular reflection of light, that is, that the reflected rays should not be dispersed and scattered one from another, there ought to be no rasures or unevenness in the reflecting surface large enough to bear a sensible proportion to the magnitude of a ray of light; because if the surface abounds with such, the reflected rays will rather be scattered like a parcel of pebbles thrown upon a rough pavement, than reflected with that regularity with which light is observed to be from a well polished surface. Now those surfaces, which to our senses appear perfectly smooth and well polished, are far from being so; for to polish, is no other than to grind off the larger eminences and protuberances of the metal with the rough and sharp particles of sand, emery, or putty, which must of necessity leave behind them an infinity of rasures and scratches, which, though inconsiderable with regard to the former roughnesses, and too minute to be discerned by us, must nevertheless bear a large proportion to, if not vastly exceed, the magnitude of the particles of light.

Secondly, it is not reflected at the second surface by impinging against any solid particles.

That it is not reflected by impinging upon the solid particles which constitute this second surface, is sufficiently clear from the foregoing argument; the second surfaces of bodies being as incapable of a perfect polish as the first: and it is farther confirmed from hence, viz. that the quantity of light reflected differs according to the different density of the medium behind the body. And that it is not reflected by impinging upon the particles which constitute the surface of the medium behind it, is evident, because the strongest reflection of all at the second surface of a body, is when there is a vacuum behind it. This therefore wants no farther proof.

II. It has been thought by some, that it is reflected at the first surface of a body, by a repulsive force equally diffused over it; and at the second, by an attractive force.

1. If there be a repulsive force diffused over the surface of bodies that repels rays of light at all times, then, since by increasing the obliquity of a ray we diminish its perpendicular force (which is that only whereby it must make its way through this repulsive force), however weakly that force may be supposed to act, rays of light may be made to fall with so great a degree of obliquity on the reflecting surface, that there shall be a total reflection of them there, and not one particle of light be able to make its way through: which is contrary to observation; the reflection of light at the first surface of a transparent body being never total in any obliquity whatever. The hypothesis therefore in this particular must be false.

2. As to the reflection at the second surface by the attractive force of the body; this may be considered in two respects: first, when the reflection is total; secondly, when it is partial.

And first, in cases where the reflection is total, the cause of it is undoubtedly that same attractive force by which light would be refracted in passing out of the same body. This is manifest from that analogy which is observable between the reflection of light at this second surface, and its refraction there. For otherwise, what can be the reason that the total reflection should begin just when the obliquity of the incident

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Nor at the
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sive force;175
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Light is
not reflec-
ted by im-
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the solid
parts of bo-
dies at the
first surface,

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Reflection.

cident ray, at its arrival at the second surface, is such that the refracted angle ought to be a right one; or when the ray, were it not to return in reflection, ought to pass on parallel to the surface, without going from it? For in this case it is evident, that it ought to be returned by this very power, and in such manner that the angle of reflection shall be equal to the angle of incidence; just as a stone thrown obliquely from the earth, after it is so far turned out of its course by the attraction of the earth, as to begin to move horizontally, or parallel to the surface of the earth, is then by the same power made to return in a curve similar to that which is described in its departure from the earth, and so falls with the same degree of obliquity that it was thrown with.

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Objected
to.

But, secondly, as to the reflection at the second surface, when it is partial; an attractive force uniformly spread over it, as the maintainers of this hypothesis conceive it to be, can never be the cause thereof. Because it is inconceivable, that the same force, acting in the same circumstances in every respect, can sometimes reflect the violet coloured rays and transmit the red, and at other times reflect the red and transmit the violet.

We have stated this objection, because it is our business to conceal no plausible opinions: but it is not valid; for in each colour, the reflection takes place at that angle, and no other, where the refraction of *that* ray would make it parallel to the posterior surface.

This partial reflection and refraction is a great difficulty in all the attempts which have been made to give a mechanical explanation of the phenomena of optics. It is equally a desideratum in that explanation which was proposed by Huygens, and, since his time, revived by Euler, by means of the undulations of an elastic fluid, although a vague consideration of undulatory motions seems to offer a very specious analogy. But a *rigid* application of such *knowledge* as we have acquired of such motions, will convince any unprejudiced mathematician, that the phenomena of undulation are essentially dissimilar to the phenomena of light. The inflection of light, and its refraction, equally demonstrate that light is *acted on* by moving forces in a direction perpendicular to the surface; and it is equally demonstrable that such forces must, in proper circumstances, produce reflections precisely such as we observe. The only difficulty is to show how there can be forces which produce both reflection and refraction, in circumstances which are similar. The fact is, that such effects are produced: the first logical inference is, that with respect to the light which is reflected and that which is refracted, the circumstances are *not* similar; and our attention should be directed to the discovery of that dissimilarity. All the phenomena of combined reflection and refraction should be examined and classed according to their generality, not doubting but that these points of resemblance will lead to the discovery of their causes. Now the experiments of Mr Bouguer show that bodies differ extremely in their powers of thus separating light by reflection and refraction, some of them reflecting much more at a given angle than others. It is not therefore a *general property of light* to be partly reflected and partly refracted, but a *distinctive property of different bodies*; and since we see that they

possess it in *different degrees*, we are authorised to conclude that some bodies *may want it altogether*. We may therefore expect some success by considering how bodies are affected by light, as well as how light is affected by bodies. Now, in all the phenomena of the material world we find bodies connected by mutual forces. We know no case where a body A tends towards a body B, or, in common language, is attracted by it, without, at the same time, the body B tending towards A. This is observed in the phenomena of magnetism, electricity, gravitation, corpuscular attraction, impulse, &c. We should therefore conclude from analogy, that as bodies change the motion of light, light also changes the motion of bodies; and that the particles near the surface are put into vibration by the passage of light through among them. Suppose a parcel of cork-balls all hanging as pendulums in a symmetrical order, and that an electrified ball passes through the midst of them; it is very easy to show that it may proceed through this assemblage in various directions with a sinuated motion, and without touching any of them, and that its ultimate direction will have a certain inclination to its primary direction, depending on the outline of the assemblage, just as is observed in the motion of light; and, in the mean time, the cork-balls will be variously agitated. Just so must it happen to the particles of a transparent body, if we suppose that they act on the particles of light by mutual attractions and repulsions.

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The objec-
tion obvi-
ated.

An attentive consideration of what happens here will show us that the superficial particles will be much more agitated than the rest; and thus a stratum be produced, which, in any instant, will act on those particles of light which are then approaching them in a manner different from that in which they will act on similarly situated particles of light, which come into the place of the first in the following moment, when these acting particles of the body have (by their motion of vibration) changed their own situation. Now it is clearly understood, that in all motions of vibration, such as the motions of pendulums, there is a moment when the body is in its natural situation, as when the pendulum is in the vertical line. This *may* happen in the same instant in each atom of the transparent body. The particles of light which *then* come within the sphere of action may be wholly reflected; in the next moment, particles of light in the very situation of the first may be refracted.

Then will arise a separation of light; and as this will depend on the manner in which the particles of bodies are agitated by it during its passage, and as this again will depend on the nature of the body, that is on the law of action of those forces which connect the particles with each other, and with the particles of light, it will be different in different bodies. But in all bodies there will be this general resemblance, that the separation will be most copious in great obliquities of incidence, which gives the repulsive forces more time for action, while it diminishes the perpendicular force of the light. Such a resemblance between the phenomena and the legitimate consequences of the assumption (the agitation of the parts of the body), gives us some authority for assigning this as the cause; nor can the assumption

Fig. 1.

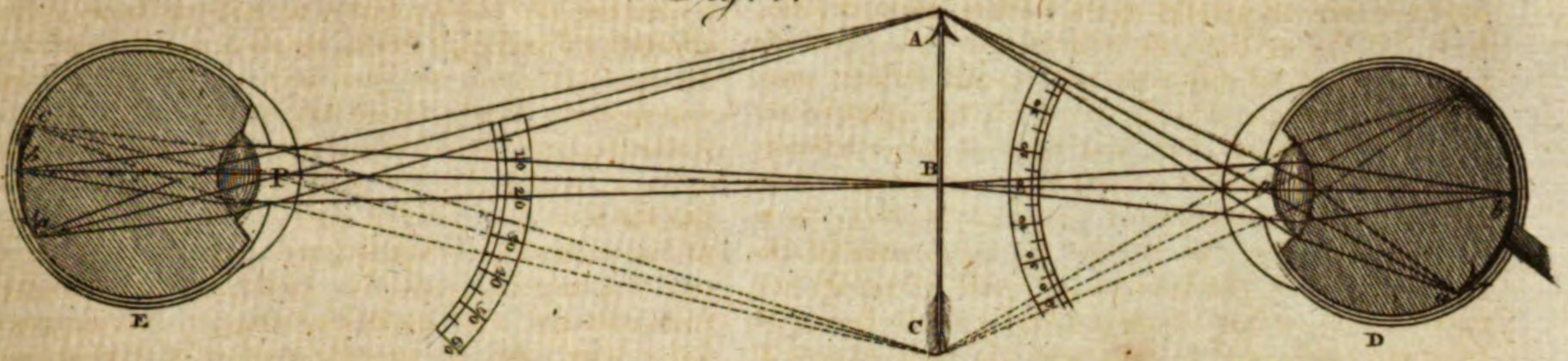


Fig. 2.

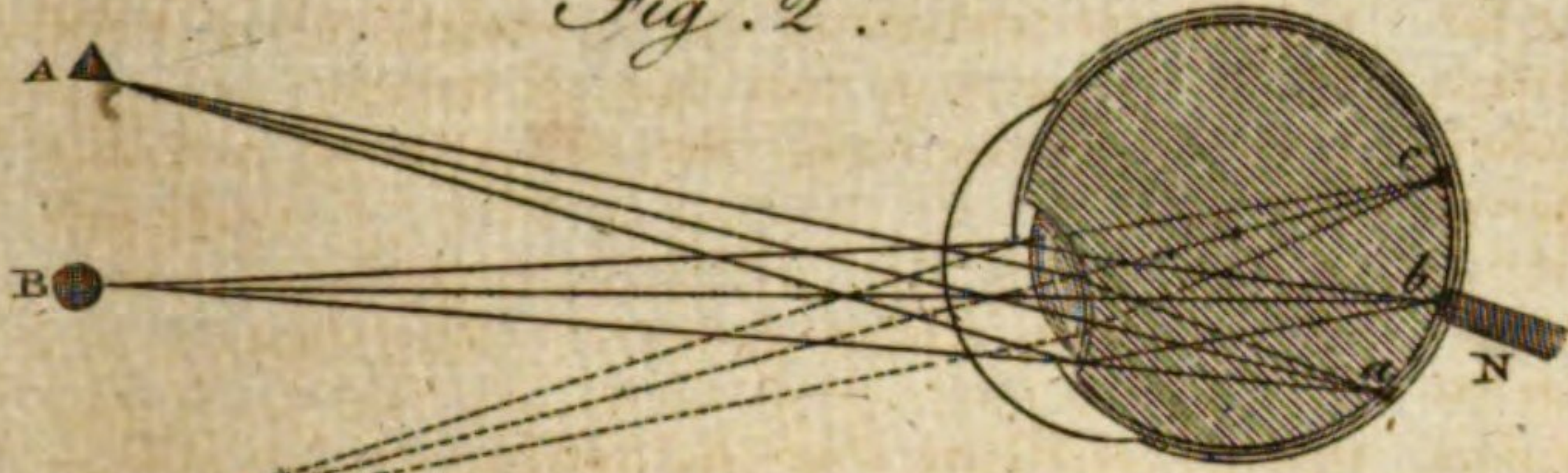


Fig. 3.

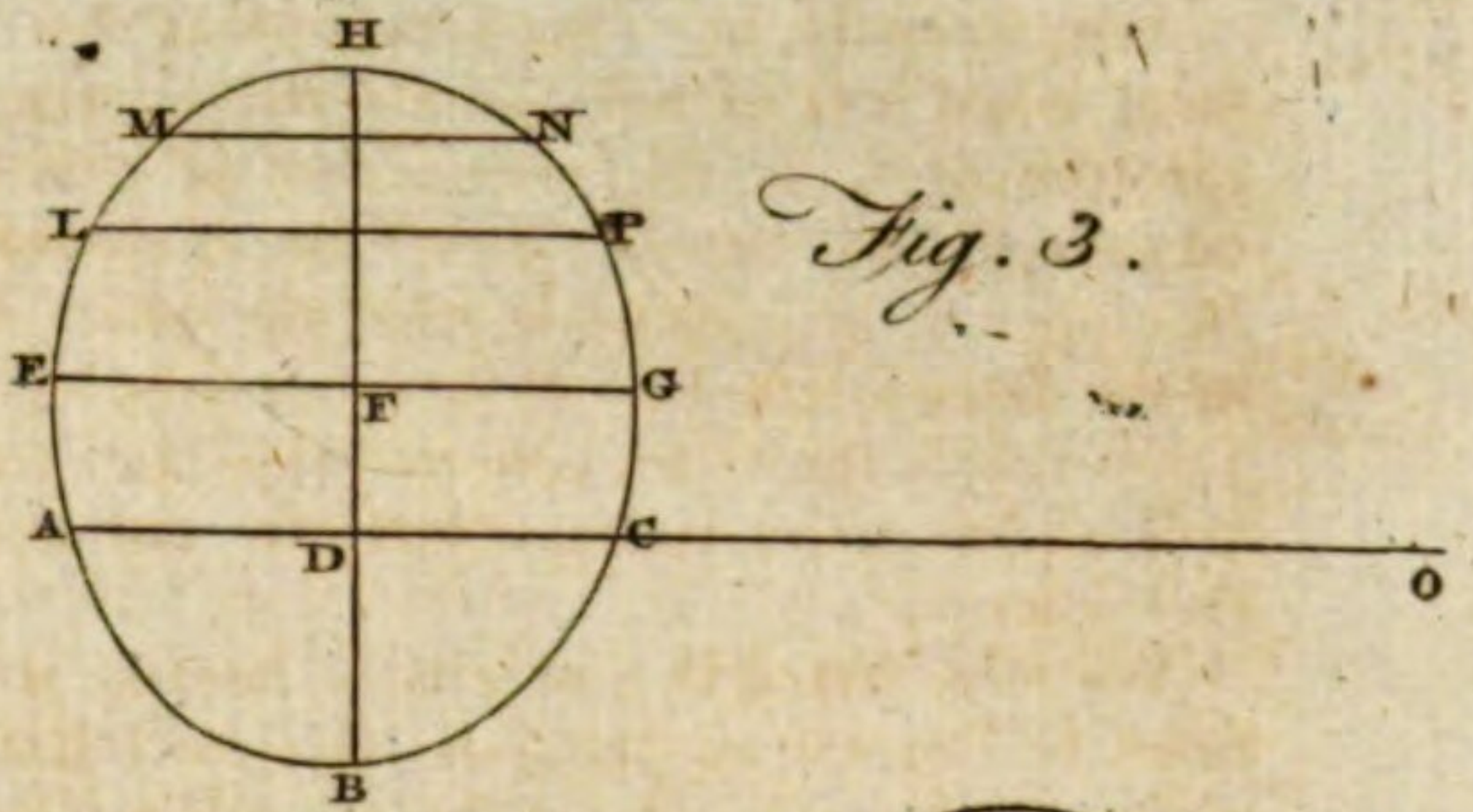


Fig. 4.

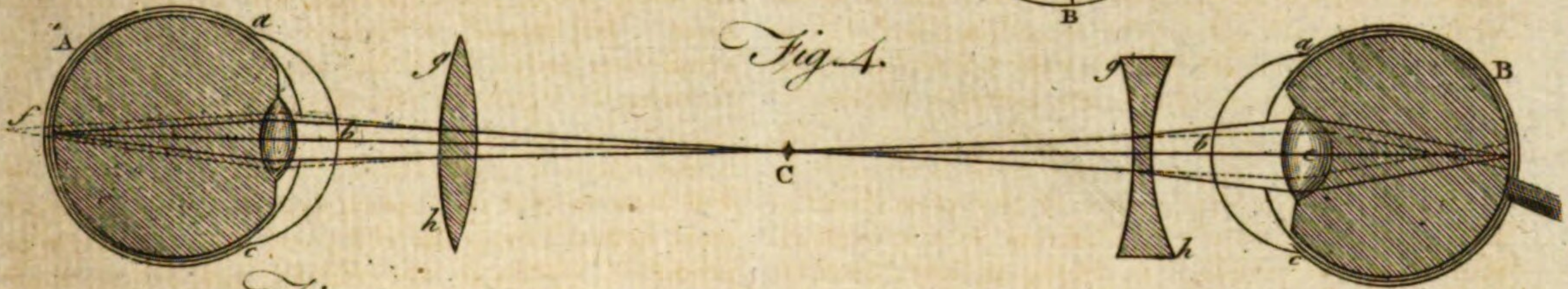


Fig. 5.

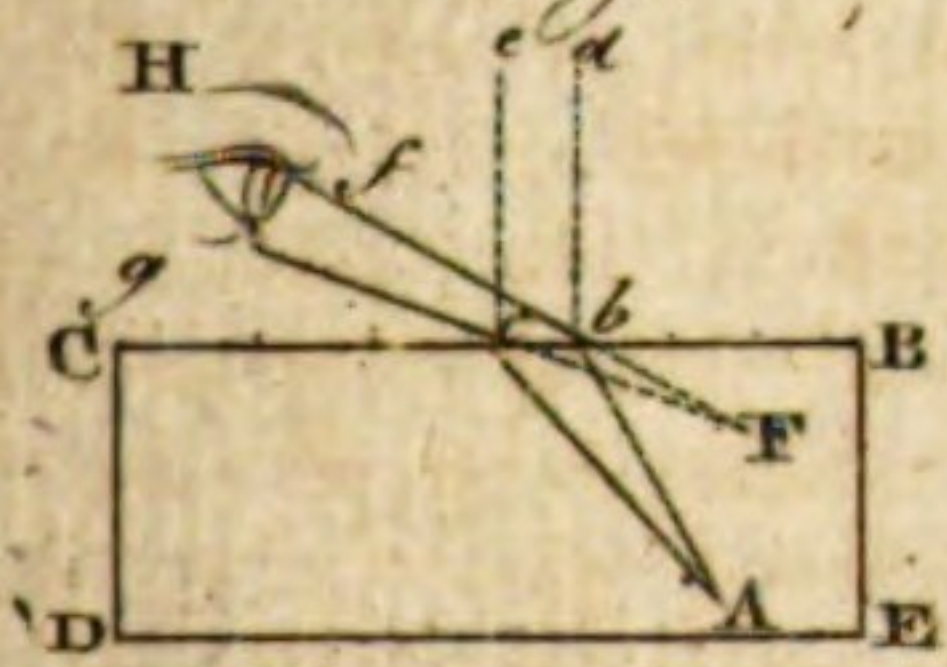


Fig. 6.

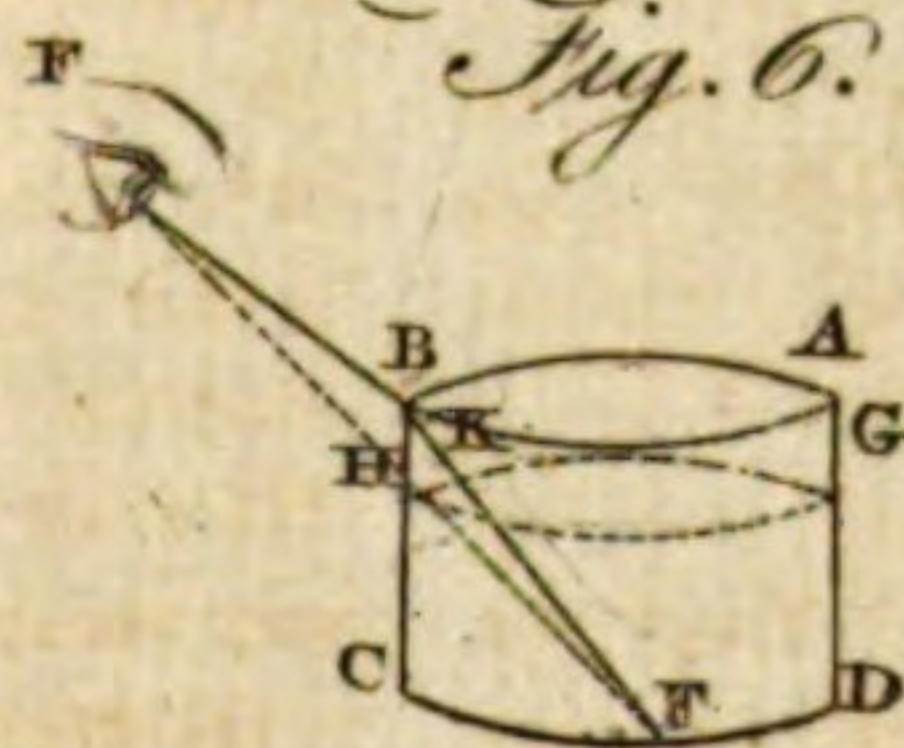


Fig. 7.

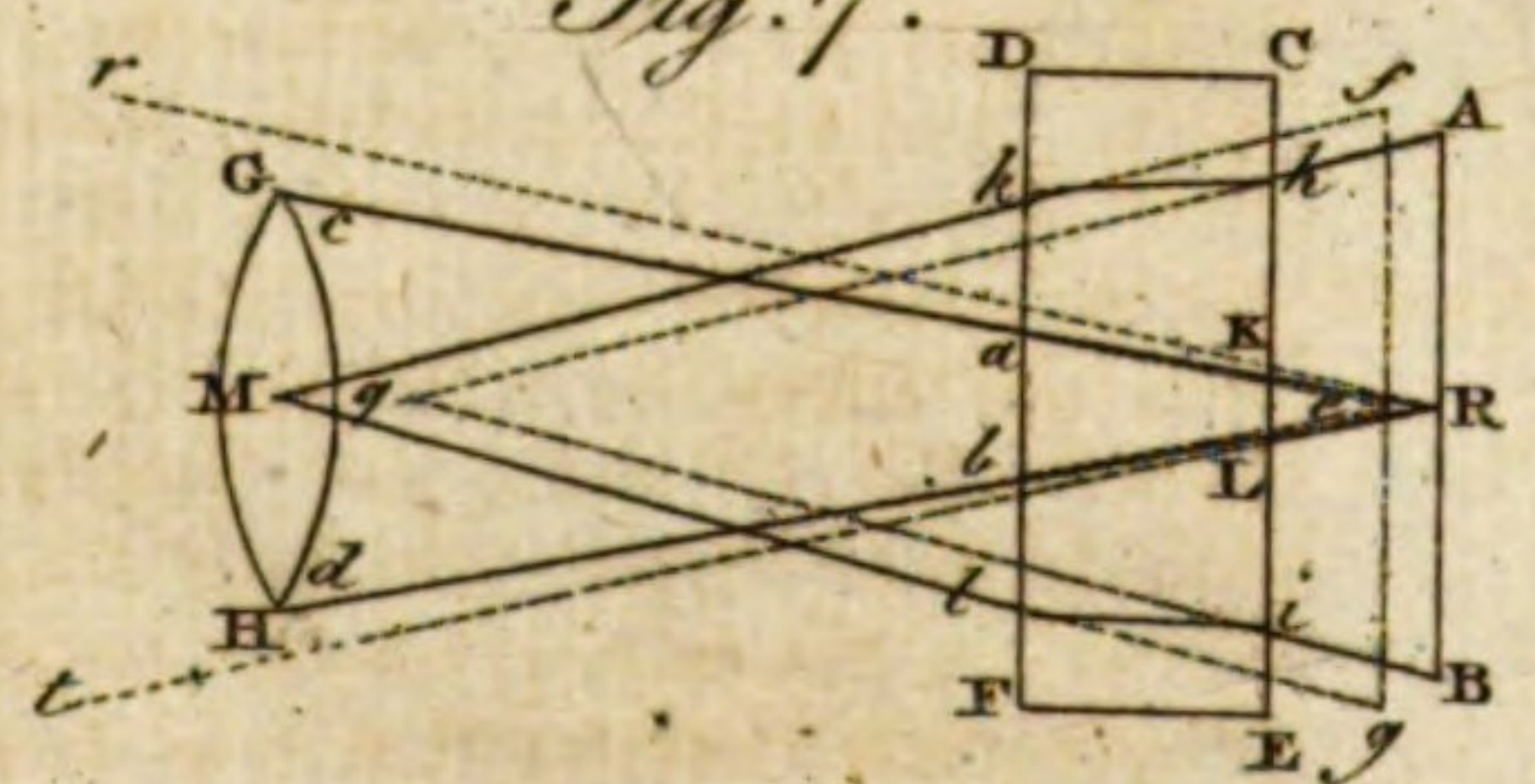


Fig. 9.

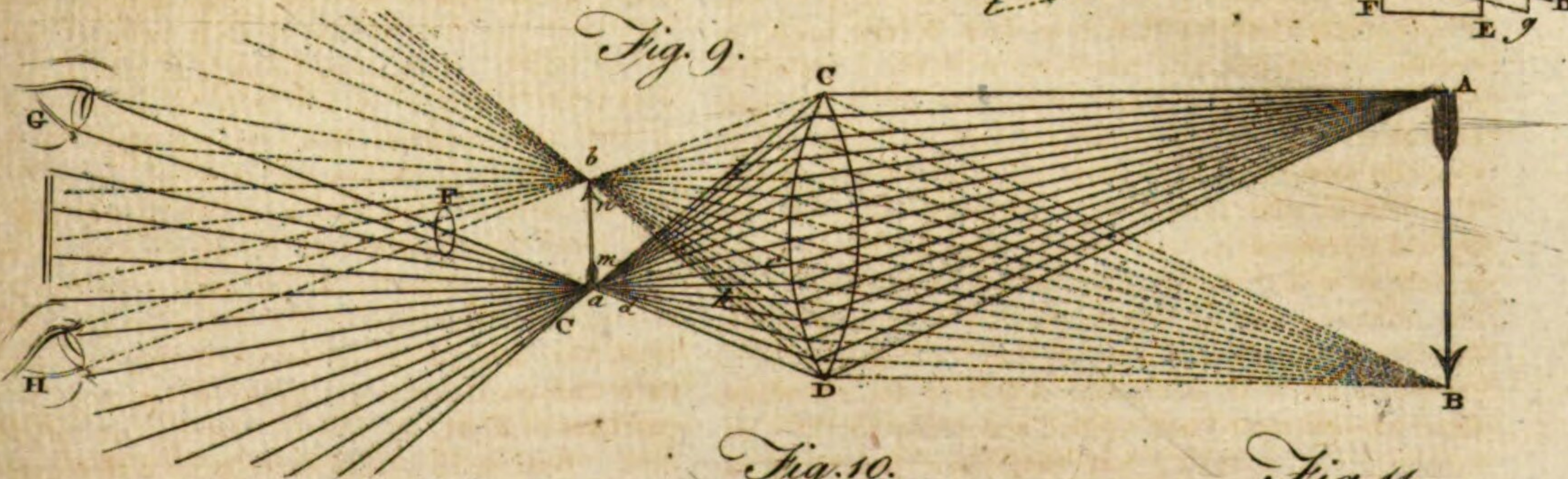


Fig. 8.

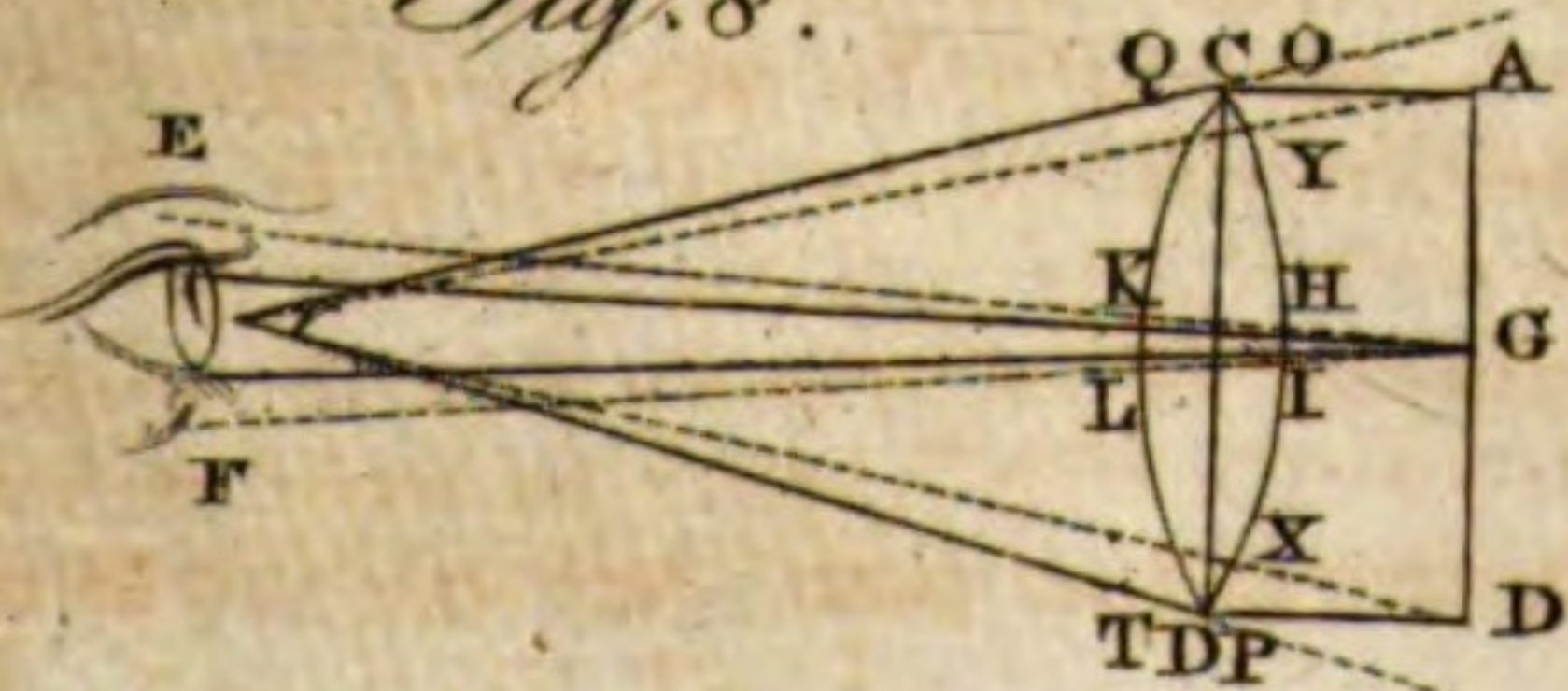


Fig. 10.

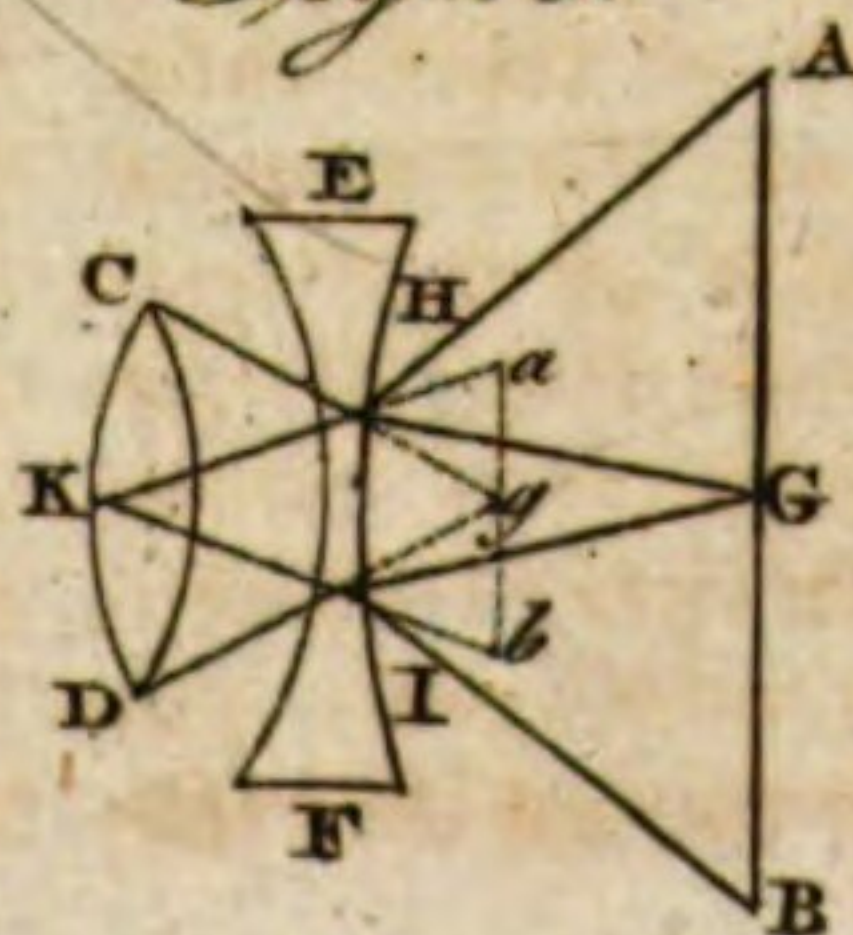
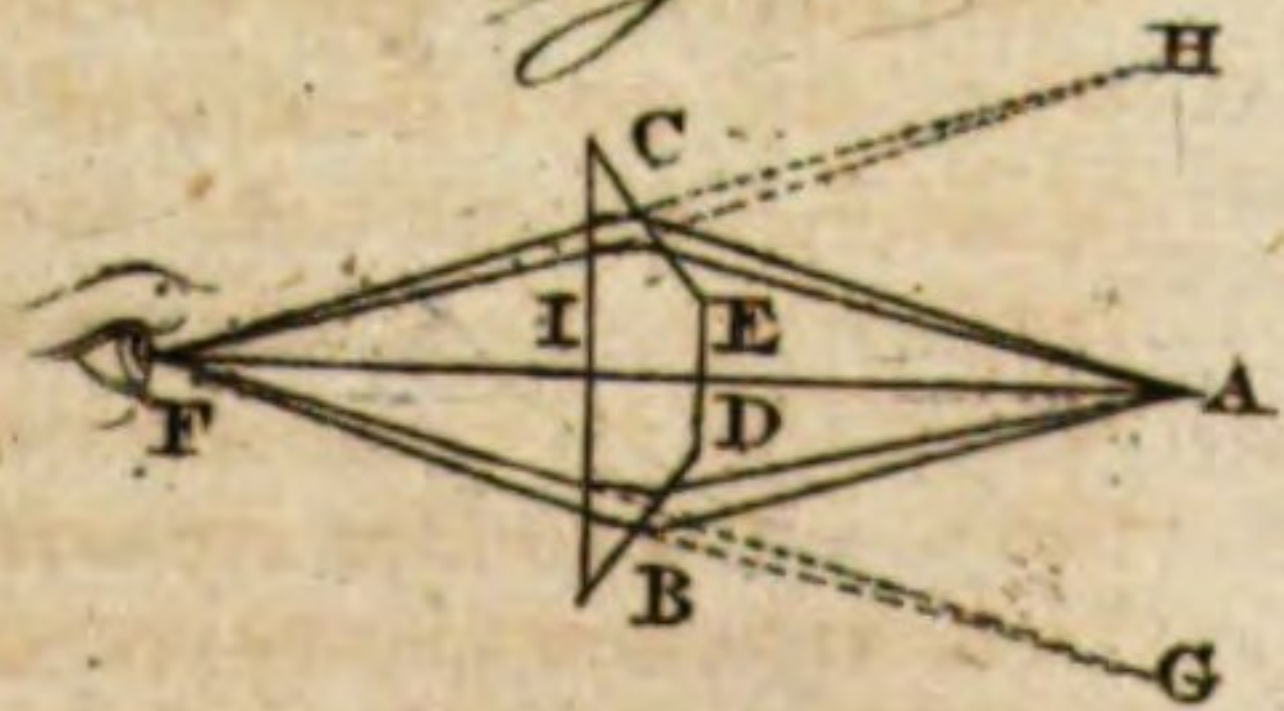


Fig. 11.



Cause of
Reflection.

tion be called *gratuitous*. To suppose that the particles of the transparent body are not thus agitated, would be a most gratuitous contradiction of a law of nature to which we know no other exception.

Thus the objection raised in n° 132. is obviated, because the reflection and refraction is not here conceived as simultaneous, but as successive.

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Another
Hypothesis.

III. Some, being apprehensive of the insufficiency of a repulsive and attractive force diffused over the surfaces of bodies and acting uniformly, have supposed, that, by the action of light upon the surface of bodies, the matter of these bodies is put into an undulatory motion; and that where the surface of it is subsiding light is transmitted, and in those places where it is rising light is reflected. But to overlook the objections which we have just made to this theory of undulation, we have only to observe, that, were it admitted, it seems not to advance us one jot farther; for in those cases, suppose where red is reflected and violet transmitted, how comes it to pass that the red impinges only on those parts when the waves are rising, and the violet when they are subsiding?

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Sir I. Newton's
Hypothesis;

IV. The next hypothesis that we shall take notice of, is that remarkable one of Sir Isaac Newton's fits of easy reflection and transmission, which we shall now explain and examine.

That author, as far as we can apprehend his meaning in this particular, is of opinion, that light in its passage from the luminous body, is disposed to be alternately reflected by and transmitted through any refracting surface it may meet with; that these dispositions (which he calls *fits of easy reflection and easy transmission*) return successively at equal intervals; and that they are communicated to it at its first emission out of the luminous body it proceeds from, probably by some very subtle and elastic substance diffused through the universe, and that in the following manner. As bodies falling into water, or passing through the air, cause undulations in each, so the rays of light may excite vibrations in this elastic substance. The quickness of which vibrations depending on the elasticity of the medium (as the quickness of the vibrations in the air, which propagate sound, depend solely on the elasticity of the air, and not upon the quickness of those in the sounding body), the motion of the particles of it may be quicker than that of the rays; and therefore, when a ray at the instant it impinges upon any surface, is in that part of a vibration of this elastic substance which conspires with its motion, it may be easily transmitted; and when it is in that part of a vibration which is contrary to its motion, it may be reflected. He farther supposes, that when light falls upon the surface of a body, if it be not in a fit of easy transmission, every ray is there put into one, so that when they come at the other side (for this elastic substance, easily pervading the pores of bodies, is capable of the same vibrations within the body as without it), the rays of one colour shall be in a fit of easy transmission, and those of another in a fit of easy reflection, according to the thickness of the body, the intervals of the fits being different in rays of a different kind. This seems to account for the different colours of the bubble and thin plate of air and water, as is obvious enough; and likewise for the reflection of light at the second surface of a

thicker body; for the light reflected from thence is also observed to be coloured, and to form rings according to the different thickness of the body, when not intermixed and confounded with other light, as will appear from the following experiment. If a piece of glass be ground concave on one side and convex on the other, both its concavity and convexity having one common centre; and if a ray of light be made to pass through a small hole in a piece of paper held in that common centre, and be permitted to fall on the glass; besides those rays which are regularly reflected back to the hole again, there will be others reflected to the paper, and form coloured rings surrounding the hole, not unlike those occasioned by the reflection of light from thin plates.

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It is ever with extreme reluctance that we venture to call in question the doctrines of Newton; but to his theory of reflection there is this insuperable objection, that it explains nothing, unless the *cause* of the fits of more easy reflection and transmission be held as legitimate, namely, that *they are produced by the undulations of another elastic fluid, incomparably more subtle than light*, acting upon it in the way of impulse. The fits themselves are *matters of fact*, and no way different from what we have endeavoured to account for: but to admit this theory of them would be to transgress every rule of philosophizing, as we have shown them to be susceptible of explanation from acknowledged optical laws.

Untenable.

§ 2. Of the Laws of Reflection.

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THE fundamental law of the reflection of light, is, that in all cases the angle of reflection is equal to the angle of incidence. This is found by experiment to be the case, and besides may be demonstrated mathematically from the laws of percussion in bodies perfectly elastic. The axiom therefore holds good in every case of reflection, whether it be from plane surfaces or spherical ones, and that whether they are convex or concave; and hence the seven following propositions relating to the reflection of light from plane and spherical surfaces may be deduced.

The fundamental law
of Reflection.

I. Rays of light reflected from a plane surface have the same degree of inclination to one another that their respective incident ones have.—For the angle of reflection of each ray being equal to that of its respective incident one, it is evident, that each reflected ray will have the same degree of inclination to that portion of the surface from whence it is reflected that its incident one has: but it is here supposed, that all those portions of surface from whence the rays are reflected, are situated in the same plain; consequently the reflected rays will have the same degree of inclination to each other that their incident ones have, from whatever part of the surface they are reflected.

II. Parallel rays reflected from a concave surface are rendered converging.—To illustrate this, let AF, CD, EB, (fig. 1.) represent three parallel rays falling upon the concave surface FB, whose centre is C. To the points F and B draw the lines CF, CB; these being drawn from the centre, will be perpendicular to the surface at those points. The incident ray CD also passing through the centre, will be perpendicular to the surface, and therefore will return after reflection in the same line; but the oblique rays AF

Plate
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Laws of reflection
from a concave surface.

and EB will be reflected into the lines FM and BM, situated on the contrary side of their respective perpendiculars CF and CB. They will therefore proceed converging after reflection towards some point, as M, in the line CD.

III. Converging rays falling on the like surface, are made to converge more.—For, every thing remaining as above, let GF, HB, be the incident rays. Now, because these rays have larger angles of incidence than the parallel ones AF and EB in the foregoing case, their angles of reflection will also be larger than those of the others; they will therefore converge after reflection, suppose in the lines FN and BN, having their point of concurrence N farther from the point C than M, that to which the parallel rays AF and EB converged to in the foregoing case; and their precise degree of convergency will be greater than that wherein they converged before reflection.

IV. Diverging rays falling upon the like surface, are, after reflection, parallel, diverging, or converging. If they diverge from the focus of parallel rays, they then become parallel; if from a point nearer to the surface than that, they will diverge, but in a less degree than before reflection; if from a point between that and the centre, they will converge after reflection, and that to some point on the contrary side of the centre, but situated farther from it than the point from which they diverged. If the incident rays diverge from a point beyond the centre, the reflected ones will converge to one on the other side of it, but nearer to it than the point they diverged from; and if they diverge from the centre, they will be reflected thither again.

1. Let them diverge in the lines MF, MB, proceeding from M, the focus of parallel rays; then, as the parallel rays AF and EB were reflected into the lines FM and BM (by Prop. II.), these rays will now on the contrary be reflected into them.

2. Let them diverge from N, a point nearer to the surface than the focus of parallel rays, they will then be reflected into the diverging lines FG and BH which the incident rays GF and HB described that were shewn to be reflected into them in the foregoing proposition; but the degree wherein they diverge will be less than that wherein they diverged before reflection.

3. Let them proceed diverging from X, a point between the focus of parallel rays and the centre; they then make less angles of incidence than the rays MF and MB, which became parallel by reflection: they will consequently have less angles of reflection, and proceed therefore converging towards some point, as Y; which point will always fall on the contrary side of the centre, because a reflected ray always falls on the contrary side of the perpendicular with respect to that on which its incident one falls; and of consequence it will be farther distant from the centre than X.

4. If the incident ones diverge from Y, they will, after reflection, converge to X; those which were the incident rays in the former case being the reflected ones in this. And lastly,

5. If the incident rays proceed from the centre, they fall in with their respective perpendiculars; and for that reason are reflected thither again.

V. Parallel rays reflected from a convex surface are rendered diverging.—For, let AB, GD, EF, (fig. 2.) be three parallel rays falling upon the convex surface BF, whose centre of convexity is C, and let one of them, viz. GD, be perpendicular to the surface. Through B, D, and F, the points of reflection, draw the lines CV, CG, and CT; which, because they pass through the centre, will be perpendicular to the surface at these points. The incident ray GD being perpendicular to the surface, will return after reflection in the same line, but the oblique ones AB and EF in the lines BK and FL, situated on the contrary side of their respective perpendiculars BV and FT. They will therefore diverge, after reflection, as from some point M in the line GD produced; and this point will be in the middle between D and C.

VI. Diverging rays reflected from the like surface are rendered more diverging.—For, every thing remaining as above, let GB, GF, be the incident rays. These having larger angles of incidence than the parallel ones AB and EF in the preceding case, their angles of reflection will also be larger than theirs: they will therefore diverge after reflection, suppose in the lines BP and FQ, as from some point N, farther from C than the point M; and the degree wherein they will diverge will be greater than that wherein they diverged before reflection.

VII. Converging rays reflected from the like surface, are parallel, converging, or diverging. If they tend towards the focus of parallel rays, they then become parallel; if to a point nearer the surface than that, they converge, but in a less degree than before reflection; if to a point between that and the centre, they will diverge after reflection, as from some point on the contrary side of the centre, but situated farther from it than the point they converged to: if the incident rays converge to a point beyond the centre, the reflected ones will diverge as from one on the contrary side of it, but nearer to it than the point to which the incident ones converged; and if the incident rays converge towards the centre, the reflected ones will proceed as from thence.

1. Let them converge in the lines KB and LF, tending towards M, the focus of parallel rays; then, as the parallel rays AB, EF were reflected into the lines BK and FL (by Prop. V.), those rays will now on the contrary be reflected into them.

2. Let them converge in the lines PB, QF, tending towards N a point nearer the surface than the focus of parallel rays, they will then be reflected into the converging lines BG and FG, in which the rays GB, GF proceeded that were shewn to be reflected into them by the last proposition: but the degree wherein they will converge will be less than that wherein they converged before reflection.

3. Let them converge in the lines RB and SF proceeding towards X, a point between the focus of parallel rays and the centre: their angles of incidence will then be less than those of the rays KB and LF, which became parallel after reflection: their angles of reflection will therefore be less; on which account they must necessarily diverge, suppose in the lines BH and FI, from some point, as Y; which point (by Prop. IV.) will fall on the contrary side of the centre

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centre with respect to X, and will be farther from it than that.

4. If the incident rays tend towards Y, the reflected ones will diverge as from X; those which were the incident ones in one case being the reflected ones in the other.

5. Lastly, if the incident rays converge towards the centre, they fall in with their respective perpendiculars; on which account they proceed after reflection as from the centre.

We have already observed, that in some cases there is a very great reflection from the second surface of a transparent body. The degree of inclination necessary to cause a total reflection of a ray at the second surface of a medium, is that which requires that the refracted angle (supposing the ray to pass out there) should be equal to or greater than a right one; and consequently it depends on the refractive power of the medium through which the ray passes, and is therefore different in different media. When a ray passes through glass surrounded with air, and is inclined to its second surface under an angle of 42 degrees or more, it will be wholly reflected there. For, as 11 is to 17 (the ratio of refraction out of glass into air), so is the sine of an angle of 42 degrees to a fourth number that will exceed the sine of a right angle. From hence it follows, that when a ray of light arrives at the second surface of a transparent substance with as great or a greater degree of obliquity than that which is necessary to make a total reflection, it will there be all returned back to the first: and if it proceeds towards that with as great an obliquity as it did towards the other (which it will do if the surfaces of the medium be parallel to each other), it will there be all reflected again, &c. and will therefore never get out, but pass from side to side, till it be wholly suffocated and lost within the body.—From hence may arise an obvious inquiry, how it comes to pass, that light falling very obliquely upon a glass window from without, should be transmitted into the room. In answer to this it must be considered, that however obliquely a ray falls upon the surface of any medium whose sides are parallel (as those of the glass in a window are), it will suffer such a degree of refraction in entering there, that it shall fall upon the second with a less obliquity than that which is necessary to cause a total reflection. For instance, let the medium be glass, as supposed in the present case: then, as 17 is to 11 (the ratio of refraction out of air into glass), so is the sine of the largest angle of incidence with which a ray can fall upon any surface to the sine of a less angle than that of total reflection. And therefore, if the sides of the glass be parallel, the obliquity with which a ray falls upon the first surface, cannot be so great, but that it shall pass the second without suffering a total reflection there.

When light passes out of a denser into a rarer medium, the nearer the second medium approaches the first in density (or more properly in its refractive power), the less of it will be refracted in passing from one to the other; and when their refracting powers are equal, all of it will pass into the second medium.

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The preceding propositions demonstrated mathematically.

The above propositions may be all mathematically demonstrated in the following manner.

PROP. I. Of the reflection of rays from a plane surface.

“When rays fall upon a plane surface, if they di-

verge, the focus of the reflected rays will be at the same distance behind the surface, that the radiant point is before it: if they converge, it will be at the same distance before the surface that the imaginary focus of the incident rays is behind it.”

This proposition admits of two cases.

CASE I. Of diverging rays.

DEM. Let AB, AC, (fig. 3.) be two diverging rays incident on the plain surface DE, the one perpendicularly, the other obliquely: the perpendicular one AB will be reflected to A, proceeding as from some point in the line AB produced; the oblique one AC will be reflected into some line as CF, such that the point G, where the line FG produced intersects the line AB produced also, shall be at an equal distance from the surface DE with the radiant A. For the perpendicular CH being drawn, ACH and HCF will be the angles of incidence and reflection; which being equal, their complements ACB and FCE are so too: but the angle BCG is equal to FCE, as being vertical to it: therefore in the triangles ABC and GBC the angles at C are equal, the side BC is common, and the angles at B are also equal to each other, as being right ones; therefore the lines AB and BG, which respect the equal angles at C, are also equal; and consequently the point G, the focus of the incident rays AB, AC, is at the same distance behind the surface, that the point A is before it. Q. E. D.

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CASE 2. Of converging rays.

This is the converse of the former case. For supposing FC and AB to be two converging incident rays, CA and BA will be the reflected ones (the angles of incidence in the former case being now the angles of reflection, and *vice versa*), having the point A for their focus; but this, from what was demonstrated above, is at an equal distance from the reflecting surface with the point G, which in this case is the imaginary focus of the incident rays FC and AB.

OBS. It is not here, as in the refraction of rays in passing through a plane surface, where some of the refracted rays proceed as from one point, and some as from another: but they all proceed after reflection as from one and the same point, however obliquely they may fall upon the surface; for what is here demonstrated of the ray AC holds equally of any other, as AI, AK, &c.

The case of parallel rays incident on a plane surface is included in this proposition: for in that case we are to suppose the radiant to be at an infinite distance from the surface, and then by the proposition the focus of the reflected rays will be so too; that is, the rays will be parallel after reflection, as they were before.

PROP. II. Of the reflection of parallel rays from a spherical surface.

“When parallel rays are incident upon a spherical surface, the focus of the reflected rays will be the middle point between the centre of convexity and the surface.”

This proposition admits of two cases.

CASE I. Of parallel rays falling upon a convex surface.

DEM. Let AB, DH, (fig. 4.) represent two parallel rays incident on the convex surface BH, the one perpendicularly, the other obliquely; and let C be the centre of convexity; suppose HE to be the reflected ray of the oblique incident one DH proceeding as from F,

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a point in the line AB produced. Through the point H draw the line CI, which will be perpendicular to the surface at that point; and the angles DHI and IHE, being the angles of incidence and reflection, will be equal. To the former of these, the angle HCF is equal, the lines AC and DH being parallel; and to the latter the angle CHF, as being vertical; wherefore the triangle CFH is isosceles, and consequently the sides CF and FH are equal: but supposing BH to vanish, FH is equal to FB; and therefore upon this supposition FC and FB are equal, that is, the focus of the reflected rays is the middle point between the centre of convexity and the surface. *Q. E. D.*

CASE 2. Of parallel rays falling upon a concave surface.

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DEM. Let AB, DH, (fig. 5.) be two parallel rays incident, the one perpendicularly, the other obliquely, on the concave surface BH, whose centre of concavity is C. Let BF and HF be the reflected rays meeting each other in F; this will be the middle point between B and C. For drawing through C the perpendicular CH, the angles DHC and FHC, being the angles of incidence and reflection, will be equal, to the former of which the angle HCF is equal, as alternate; and therefore the triangle CFH is isosceles. Wherefore CF and FH are equal: but if we suppose BH to vanish, FB and FH are also equal, and therefore CF is equal to FB; that is, the focal distance of the reflected rays is the middle point between the centre and the surface. *Q. E. D.*

Obs. It is here observable, that the farther the line DH, either in fig. 4. or 5. is taken from AB, the nearer the point F falls to the surface. For the farther the point H recedes from B, the larger the triangle CFH will become; and consequently, since it is always an isosceles one, and the base CH, being the radius, is everywhere of the same length, the equal legs CF and FH will lengthen; but CF cannot grow longer unless the point F approach towards the surface. And the farther H is removed from B, the faster F approaches to it.

This is the reason, that whenever parallel rays are considered as reflected from a spherical surface, the distance of the oblique one from the perpendicular one is taken so small with respect to the focal distance of that surface, that without any physical error it may be supposed to vanish.

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Reflected
rays from
a spherical
surface ne-
ver proceed
from the
same point

From hence it follows, that if a number of parallel rays, as AB, CD, EG, &c. fall upon a convex surface, (as fig. 6.) and if BA, DK, the reflected rays of the incident ones AB, CD, proceed as from the point F, those of the incident ones CD, EG, viz. DK, GL, will proceed as from N, those of the incident ones EG, HI, as from O, &c. because the farther the incident ones CD, EG, &c. are from AB, the nearer to the surface are the points F, f, f, in the line BF, from which they proceed after reflection; so that properly the foci of the reflected rays BA, DK, GL, &c. are not in the line AB produced, but in a curve line passing through the points F, N, O, &c.

The same is applicable to the case of parallel rays reflected from a concave surface, as expressed by the pricked lines on the other half of the figure, where PQ, RS, TV, are the incident rays; QF, Sf, Vf, the reflected ones, intersecting each other in the points

X, Y, and F; so that the foci of those rays are not in the line FB, but in a curve passing through those points.

Had the surface BH in fig. 4. or 5. been formed by the revolution of a parabola about its axis having its focus in the point F, all the rays reflected from the convex surface would have proceeded as from the point F, and those reflected from the concave would have fallen upon it, however distant their incident ones AB, DH, might have been from each other. For in the parabola, all lines drawn parallel to the axis make angles with the tangents to the points where they cut the parabola (that is, with the surface of the parabola) equal to those which are made with the same tangents by lines drawn from thence to the focus; therefore, if the incident rays describe those parallel lines, the reflected ones will necessarily describe these other, and so will all proceed as from, or meet in, the same point.

PROP. III. Of the reflection of diverging and converging rays from a spherical surface.

“When rays fall upon any spherical surface, if they diverge, the distance of the focus of the reflected rays from the surface is to the distance of the radiant point from the same (or, if they converge, to that of the imaginary focus of the incident rays), as the distance of the focus of the reflected rays from the centre is to the distance of the radiant point (or imaginary focus of the incident rays) from the same.”

This proposition admits of ten cases.

CASE 1. Of diverging rays falling upon a convex surface.

DEM. Let RB, RD (fig. 7.) represent two diverging rays flowing from the point R as from a radiant, and falling the one perpendicularly, the other obliquely, on the convex surface BD, whose centre is C. Let DE be the reflected ray of the incident one RD, produce ED to F, and through R draw the line RH parallel to FE till it meets CD produced in H. Then will the angle RHD be equal to EDH the angle of reflection, as being alternate to it, and therefore equal also to RDH which is the angle of incidence; wherefore the triangle DRH is isosceles, and consequently DR is equal to RH. Now the lines FD and RH being parallel, the triangles FDC and RHC are similar, (or, to express it in Euclid's way, the sides of the triangle RHC are cut proportionably, 2 Elem. 6.): and therefore FD is to RH, or its equal RD, as CF to CR; but BD vanishing, FD and RD differ not from FB and RB: wherefore FB is to RB also, as CF to CR; that is, the distance of the focus from the surface is to the distance of the radiant point from the same, as the distance of the focus from the centre is to the distance of the radiant from thence. *Q. E. D.*

CASE 2. Of converging rays falling upon a concave surface.

DEM. Let KD and CB be the converging incident rays having their imaginary focus in the point R, which was the radiant in the foregoing case. Then as RD was in that case reflected into DE, KD will in this be reflected into DF; for, since the angles of incidence in both cases are equal, as they are by being vertical, the angles of reflection will be so too; so that F will be the focus of the reflected rays: but it

was there demonstrated, that FB is to RB as CF to CR ; that is, the distance of the focus from the surface is to the distance (in this Case) of the imaginary focus of the incident rays, as the distance of the focus from the centre is to the distance of the imaginary focus of the incident rays from the same. $\mathcal{Q}. E. D.$

CASE 3. Of converging rays falling upon a convex surface, and tending to a point between the focus of parallel rays and the centre.

Plate CCCLIX. DEM. Let BD (fig. 8.) represent a convex surface whose centre is C , and whose focus of parallel rays is P ; and let AB, KD , be two converging rays incident upon it, and having their imaginary focus at R , a point between P and C . Now because KD tends to a point between the focus of parallel rays and the centre, the reflected ray DE will diverge from some point on the other side the centre, suppose F ; as explained above (p. 308.) under prop. 7. Through D draw the perpendicular CD , and produce it to H ; then will KDH and HDE be the angles of incidence and reflection, which being equal, their vertical ones RDC and CDF will be so too, and therefore the vertex of the triangle RDF is bisected by the line DC : wherefore (3 El. 6.) FD and DR , or, BD vanishing, FB and BR are to each other as FC to CR ; that is, the distance of the focus of the reflected rays is to that of the imaginary focus of the incident ones, as the distance of the former from the centre is to the distance of the latter from the same. $\mathcal{Q}. E. D.$

CASE 4. Of diverging rays falling upon a concave surface, and proceeding from a point between the focus of parallel rays and the centre.

DEM. Let RB, RD , (fig. 8.) be the diverging rays incident upon the concave surface BD , having their radiant point in the point R , the imaginary focus of the incident rays in the foregoing case. Then as KD was in that case reflected into DE , RD will now be reflected into DF . But it was there demonstrated, that FB and RB are to each other as CF to CR ; that is, the distance of the focus is to that of the radiant as the distance of the former from the centre is to the distance of the latter from the same. $\mathcal{Q}. E. D.$

The angles of incidence and reflection being equal, it is evident, that if, in any case, the reflected ray be made the incident one, the incident will become the reflected one; and therefore the four following cases may be considered respectively as the converse of the four foregoing; for in each of them the incident rays are supposed to coincide with the reflected ones in the other. Or they may be demonstrated independently of them as follows.

CASE 5. Of converging rays falling upon a convex surface, and tending to a point nearer the surface than the focus of parallel rays.

DEM. Let ED, RB (fig. 7.) be the converging rays incident upon the convex surface BD whose centre is C , and focus of parallel rays is P ; and let the imaginary focus of the incident rays be at F , a point between P and B ; and let DR be the reflected ray. From C and R draw the lines CH, RH , the one passing through D , the other parallel to FE . Then will the angle RHD be equal to HDE the angle of incidence, as alternate to it; and therefore

equal to HDR , the angle of reflection: wherefore the triangle HDR is isosceles, and consequently DR is equal to RH . Now the lines FD and RH being parallel, the triangles FDC and RHC are similar; and therefore RH , or RD , is to FD as CR to CF : but BD vanishing, RD and FD coincide with RB and FB , wherefore RB is to FB as CR to CF ; that is, the distance of the focus from the surface is to the distance of the imaginary focus of the incident rays, as the distance of the focus from the centre is to the distance of the imaginary focus of the incident rays from the same. $\mathcal{Q}. E. D.$

CASE 6. Of diverging rays falling upon a concave surface, and proceeding from a point between the focus of parallel rays and the surface.

DEM. Let FD and FB represent two diverging rays flowing from the point F as a radiant, which was the imaginary focus of the incident rays in the foregoing case. Then as ED was in that case reflected into DR , FD will be reflected into DK (for the reason mentioned in Case 2.), so that the reflected ray will proceed as from the point R : but it was demonstrated in the case immediately foregoing, that RB is to FB as CR to CF ; that is, the distance of the focus from the surface is to that of the radiant from the same, as the distance of the former from the centre is to that of the latter from the same. $\mathcal{Q}. E. D.$

CASE 7. Of converging rays falling upon a convex surface, and tending towards a point beyond the centre.

DEM. Let AB, ED (fig. 8.) be the incident rays tending to F , a point beyond the centre C , and let DK be the reflected ray of the incident one ED . Then because the incident ray ED tends to a point beyond the centre, the reflected ray DK will proceed as from one on the contrary side, suppose R ; as explained above under Prop. VII. Through D draw the perpendicular CD , and produce it to H . Then will EDH and HDK be the angles of incidence and reflection; which being equal, their vertical ones CDE and CDR will be so too: consequently the vertex of the triangle FDR is bisected by the line CD : wherefore, RD is to DF , or (3 Elem. 6.) BD vanishing, RB is to BF as RC to CF ; that is, the distance of the focus of the reflected rays is to that of the imaginary focus of the incident rays, as the distance of the former from the centre is to the distance of the latter from the same. $\mathcal{Q}. E. D.$

CASE 8. Of diverging rays falling upon a concave surface, and proceeding from a point beyond the centre.

DEM. Let FB, FD , be the incident rays having their radiant in F , the imaginary focus of the incident rays in the foregoing case. Then as ED was in that case reflected into DK , FD will now be reflected into DR ; so that R will be the focus of the reflected rays. But it was demonstrated in the foregoing case, that RB is to FB as RC to CF ; that is, the distance of the focus of the reflected rays from the surface is to the distance of the radiant from the same, as the distance of the focus of the reflected rays from the centre is to the distance of the radiant from thence. $\mathcal{Q}. E. D.$

The two remaining cases may be considered as the converse of those under Prop. II. (p. 309, 310.), because the

the incident rays in these are the reflected ones in them; or they may be demonstrated in the same manner with the foregoing, as follows.

CASE 9. Converging rays falling upon a convex surface, and tending to the focus of parallel rays, become parallel after reflection.

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DEM. Let ED, RB (fig. 7.), represent two converging rays incident on the convex surface BD, and tending towards F, which we will now suppose to be the focus of parallel rays; and let DR be the reflected ray, and C the centre of convexity of the reflecting surface. Through C draw the line CD, and produce it to H, drawing RH parallel to ED produced to F. Now it has been demonstrated (Case 5. where the incident rays are supposed to tend to the point F), that RB is to FB as RC to CF; but F in this Case being supposed to be the focus of parallel rays, it is the middle point between C and B (by Prop. II.), and therefore FB and FC are equal; and consequently the two other terms in the proportion, viz RB and RC, must be so too; which can only be upon the supposition that R is at an infinite distance from B; that is, that the reflected rays BR and DR be parallel. Q. E. D.

CASE 10. Diverging rays falling upon a concave surface, and proceeding from the focus of parallel rays, become parallel after reflection.

DEM. Let RD, RB (fig. 8.), be two diverging rays incident upon the concave surface BD, as supposed in Case 4. where it was demonstrated that FB is to RB as CF to CR. But in the present case RB and CR are equal, because R is supposed to be the focus of parallel rays; therefore FB and FC are so too: which cannot be unless F be taken at an infinite distance from B; that is, unless the reflected rays BF and DF be parallel. Q. E. D.

OBS. It is here observable, that in the case of diverging rays falling upon a convex surface (see fig. 7.), the farther the point D is taken from B, the nearer the point F, the focus of the reflected rays, approaches to B, while the radiant R remains the same. For it is evident from the curvature of a circle, that the point D (fig. 9.) may be taken so far from B, that the reflected ray DE shall proceed as from F, G, H, or even from B, or from any point between B and R; and the farther it is taken from B, the faster the point from which it proceeds approaches towards R: as will easily appear if we draw several incident rays with their respective reflected ones, in such manner that the angles of reflection may be all equal to their respective angles of incidence, as is done in the figure. The like is applicable to any of the other cases of diverging or converging rays incident upon a spherical surface. This is the reason, that when rays are considered as reflected from a spherical surface, the distance of the oblique rays from the perpendicular one is taken so small, that it may be supposed to vanish.

From hence it follows, that if a number of diverging rays are incident upon the convex surface BD at the several points B, D, D, &c. they shall not proceed after reflection as from any point in the line RB produced, but as from a curve line passing through the several points F, f, f, &c. The same is applicable in all the other cases.

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Had the curvature BD (fig. 7.) been hyperbolic, having its foci in R and F; then R being the radiant (or the imaginary focus of incident rays), F would have been the focus of the reflected ones, and *vice versa*, however distant the points B and D might be taken from each other. In like manner, had the curve BD (fig. 8.) been elliptical, having its foci in F and R, the one of these being made the radiant (or imaginary focus of incident rays), the other would have been the focus of reflected ones, and *vice versa*. For both in the hyperbola and ellipsis, lines drawn from each of their foci through any point make equal angles with the tangent to that point. Therefore, if the incident rays proceed to or from one of their foci, the reflected ones will all proceed as from or to the other. So that, in order that diverging or converging rays may be accurately reflected to or from a point, the reflecting surface must be formed by the revolution of an *hyperbola* about its longer axis, when the incident rays are such, that their radiant or imaginary focus of incident rays shall fall on one side the surface, and the focus of the reflected ones on the other: when they are both to fall on the same side, it must be formed by the revolution of an *ellipsis* about its longer axis. However, upon account of the great facility with which spherical surfaces are formed in comparison of that with which surfaces formed by the revolution of any of the conic sections about their axes are made, the latter are very rarely used. Add to this another inconvenience, viz. that the foci of these curves being mathematical points, it is but one point of the surface of an object that can be placed in any of them at a time; so that it is only in theory that surfaces formed by the revolution of these curves about their axes render reflection perfect.

Now, because the focal distance of rays reflected from a spherical surface cannot be found by the analogy laid down in the third proposition, without making use of the quantity sought; we shall here give an instance whereby the method of doing it in all others will readily appear.

PROB. Let it be required to find the focal distance of diverging rays incident upon a convex surface, whose radius of convexity is 5 parts, and the distance of the radiant from the surface is 20.

SOL. Call the focal distance sought x ; then will the distance of the focus from the centre be $5-x$, and that of the radiant from the same 25 ; therefore by prop. 3. we have the following proportion, viz. $x : 20 :: 5 - x : 25$; and multiplying extremes together and means together, we have $25x = 100 - 20x$, which, after due reduction, gives $x = \frac{100}{45}$.

If in any case it should happen that the value of x should be a negative quantity, the focal point must then be taken on the contrary side of the surface to that on which it was supposed that it would fall in stating the problem.

If letters instead of figures had been made use of in the foregoing solution, a general theorem might have been raised, to have determined the focal distance of reflected rays in all cases whatever. See this done in Suppl. to Gregory's Optics, 2d edit. p. 112.

Because it was, in the preceding section, observed, that different incident rays, though tending to or from one point, would after refraction proceed to or from

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different points, a method was there inserted of determining the distinct point which each separate ray entering a spherical surface converges to, or diverges from, after refraction: the same has been observed here with regard to rays reflected from a spherical surface (see Obs. in Case 2. and Case 10.) But the method of determining the distinct point to or from which any given incident ray proceeds after reflection, is much more simple. It is only necessary to draw the reflected ray such, that the angle of reflection may be equal to the angle of incidence, which will determine the point it proceeds to or from in any case whatever.

§ 3. *Of the Appearance of Bodies seen by Light reflected from plane and spherical Surfaces.*

WHATEVER has been said concerning the appearance of bodies seen by refracted light through lenses, respects also the appearance of bodies seen by reflection. But besides these, there is one thing peculiar to images by reflection, viz. that each point in the representation of an object made by reflection appears situated somewhere in an infinite right line that passes through its correspondent point in the object, and is perpendicular to the reflecting surface.

The truth of this appears sufficiently from the propositions formerly laid down: in each of which, rays flowing from any radiant point, are shown to proceed after reflection to or from some point in a line that passes through the said radiant, and is perpendicular to the reflecting surface. For instance (fig. 1.), rays flowing from Y are collected in X, a point in the perpendicular CD, which, being produced, passes through Y: again (fig. 2.), rays flowing from G, proceed, after reflection, as from N, a point in the perpendicular CD, which, being produced, passes through G; and so of the rest.

This observation, however, except where an object is seen by reflection from a plain surface, relates only to those cases where the representation is made by means of such rays as fall upon the reflecting surface with a very small degree of obliquity; because such as fall at a considerable distance from the perpendicular, proceed not after reflection as from any point in that perpendicular, but as from other points situated in a certain curve, as hath already been explained; upon which account these rays are neglected, as making a confused and deformed representation. And therefore it is to be remembered, that however the situation of the eye with respect to the object and reflecting surface may be represented in the following figures, it is to be supposed as situated in such a manner with respect to the object, that rays flowing from thence and entering it after reflection, may be such only as fall with a very small degree of obliquity upon the surface; that is, the eye must be supposed to be placed almost directly behind the object, or between it and the reflecting surface. The reason why it is not always so placed, is only to avoid confusion in the figures.

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pearance of
objects re-
flected
from plane
surfaces.

I. When an object is seen by reflection from a plane surface, the image of it appears at the same distance behind the surface that the object is placed before it, of the same magnitude therewith, and directly opposite to it.

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To explain this, let AB (fig. 10) represent an object seen by reflection from the plain surface SV; and let the rays AF, AG, be so inclined to the surface, that they shall enter an eye at H after reflection; and let AE be perpendicular to the surface: then, by the observation just mentioned, the point A will appear in some part of the line AE produced, suppose I; that is, the oblique rays AF and AG will proceed after reflection as from that point; and further, because the reflected rays FH, GK, will have the same degree of inclination to one another that their incident ones have, that point must necessarily be at the same distance from the surface that the point A is; the representation therefore of the point A will be at the same distance behind the surface that the point itself is before it, and directly opposite to it: consequently, since the like may be shown of the point B, or of any other, the whole image IM will appear at the same distance behind the surface that the object is before it, and directly opposite to it; and because the lines AI, BM, which are perpendicular to the plain surface, are for that reason parallel to each other, it will also be of the same magnitude therewith.

II. When an object is seen by reflection from a convex surface, its image appears nearer to the surface, and less than the object.

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Let AB (fig. 12.) represent the object, SV a reflecting surface whose centre of convexity is C: and let the rays AF, AG, be so inclined to the surface, that after reflection therefrom, they shall enter the eye at H: and let AE be perpendicular to the surface; then will the oblique rays AF, AG, proceed after reflection as from some point in the line AE produced, suppose from I; which point, because the reflected rays will diverge more than the incident ones, must be nearer to the surface than the point A. And since the same is also true of the rays which flow from B, or any other point, the representation IM will be nearer to the surface than the object; and because it is terminated by the perpendiculars AE and BF, which incline to each other, as concurring at the centre, it will also appear less.

III. When an object is seen by reflection from a concave surface, the representation of it is various, both with regard to its magnitude and situation, according as the distance of the object from the reflecting surface is greater or less.

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From con-
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1. When the object is nearer to the surface than its focus of parallel rays, the image falls on the opposite side of the surface, is more distant from it, and larger than the object.

Thus, let AB (fig. 13.) be the object, SV the reflecting surface, F the focus of parallel rays, and C its centre. Through A and B, the extremities of the object, draw the lines CE, CR, which will be perpendicular to the surface; and let the rays AR, AG, be incident upon such points of it that they shall be reflected into an eye at H. Now, because the radiant points A and B are nearer the surface than F the focus of parallel rays, the reflected rays will diverge, and will therefore proceed as from some points on the opposite side of the surface; which points, by the observation laid down at the beginning of this section, will be in the perpendiculars AE, BR, produced, suppose in I and M: but they will diverge in a less

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degree than their incident ones (see the proposition just referred to); and therefore the said points will be farther from the surface than the points A and B. The image therefore will be on the opposite side of the surface with respect to the object: it will be more distant than it; and consequently being terminated by the perpendiculars CI and CM, it will also be larger.

2. When the object is placed in the focus of parallel rays, the reflected rays enter the eye parallel; in which case the image ought to appear at an infinite distance behind the reflecting surface: but the representation of it, for the like reasons that were given in the foregoing case, being large and distinct, we judge it not much farther from the surface than the image.

3. When the object is placed between the focus of parallel rays and the centre, the image falls on the opposite side of the centre, is larger than the object, and in an inverted position.

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Thus let AB (fig. 14.) represent the object, SV the reflecting surface, F its focus of parallel rays, and C its centre. Through A and B, the extremities of the object, draw the lines CE and CN, which will be perpendicular to the surface; and let AR, AG, be a pencil of rays flowing from A. These rays proceeding from a point beyond the focus of parallel rays, will after reflection converge towards some point on the opposite side the centre, which will fall upon the perpendicular EC produced, but at a greater distance from C than the radiant A from which they diverged. For the same reason, rays flowing from B will converge to a point in the perpendicular NC produced, which shall be farther from C than the point B; from whence it is evident, that the image IM is larger than the object AB, that it falls on the contrary side the centre, and that their positions are inverted with respect to each other.

4. If the object be placed beyond the centre of convexity, the image is then formed between the centre and the focus of parallel rays, is less than the object, and its position is inverted.

This proposition is the converse of the foregoing: for as in that case rays proceeding from A were reflected to I, and from B to M; so rays flowing from I and M will be reflected to A and B; if therefore an object be supposed to be situated beyond the centre in IM, the image of it will be formed in AB between that and the focus of parallel rays, will be less than the object, and inverted.

5. If the middle of the object be placed in the centre of convexity of the reflecting surface, the object and its image will be coincident; but the image will be inverted with respect to the object.

That the place of the image and the object should be the same in this case needs little explication; for the middle of the object being in the centre, rays flowing from thence will fall perpendicularly upon the surface, and therefore necessarily return thither again; so that the middle of the image will be coincident with the middle of the object. But that the image should be inverted is perhaps not so clear. To explain this, let AB (fig. 15.) be the object, having its middle point C in the centre of the reflecting sur-

face SV; through the centre and the point R draw the line CR, which will be perpendicular to the reflecting surface; join the points AR and BR, and let AR represent a ray flowing from A; this will be reflected into RB: for C being the middle point between A and B, the angles ARC and CRB are equal; and a ray from B will likewise be reflected to A; and therefore the position of the image will be inverted with respect to that of the object.

In this proposition it is to be supposed, that the object AB is so situated with respect to the reflecting surface, that the angle ACR may be right; for otherwise the angles ARC and BRC will not be equal, and part of the image will therefore fall upon the object and part off.

6. If in any of the three last cases, in each of which the image is formed on the same side of the reflecting surface with the object, the eye be situated farther from the surface than the place where the image falls, the rays of each pencil, crossing each other in the several points of the image, will enter the eye as from a real object situated there; so that the image will appear pendulous in the air between the eye and the reflecting surface, and in the position wherein it is formed, viz. inverted with respect to the object, in the same manner that an image formed by refracted light appears to an eye placed beyond it; which was fully explained under Prop. IV. (p. 304.), and therefore needs not be repeated.

But as what relates to the appearance of the object when the eye is placed nearer to the surface than the image, was not there fully inquired into, that point shall now be more strictly examined under the following case, which equally relates to refracted and reflected light.

7. If the eye be situated between the reflecting surface and the place of the image, the object is then seen beyond the surface; and the farther the eye recedes from the surface towards the place of the image, the more confused, larger, and nearer, the object appears.

To explain this, let AB (fig. 16.) represent the object; IM its image, one of whose points M is formed by the concurrence of the reflected rays DM, EM, &c. which before reflection came from B; the other, I, by the concurrence of DI, EI, &c. which came from A: and let *ab* be the pupil of an eye, situated between the surface DP and the image. This pupil will admit the rays *Ha*, *Kb*; which, because they are tending towards I, are such as came from A, and therefore the point A will appear diffused over the space RS. In like manner the pupil will also receive into it the reflected rays *Ka* and *Lb*, which, because they are tending towards M, by supposition came from B; and therefore the point B will be seen spread as it were over the space TV, and the object will seem to fill the space RV; but the representation of it will be confused, because the intermediate points of the object being equally enlarged in appearance, there will not be room for them between the points S and T, but they will coincide in part one with another: for instance, the appearance of that point in the object, whose representation falls upon *c* in the image, will fill the space *mn*; and so of the rest. Now, if the same pupil

The Ap-
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of Bodies
seen by Re-
flection
from diffe-
rent Surfa-
ces.

pupil be removed into the situation ef , the reflected rays Ee and Gf will then enter the eye, and therefore one extremity of the object will appear to cover the space XY ; and because the rays Of and Le will also enter it in their progress towards M , the point B , from whence they came, will appear to cover ZV ; the object therefore will appear larger and more confused than before. And when the eye recedes quite to the image, it sees but one single point of the object, and that appears diffused all over the reflecting surface: for instance, if the eye recedes to the point M , then rays flowing from the point B enter it upon whatever part of the surface they fall; and so for the rest. The object also appears nearer to the surface the farther the eye recedes from it towards the place of the image; probably because, as the appearance of the object becomes more and more confused, its place is not so easily distinguished from that of the reflecting surface itself, till at last when it is quite confused (as it is when the eye is arrived at M) they both appear as one, the surface assuming the colour of the object.

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The ap-
parent
magnitude
of an object
seen by re-
flection
from a con-
cave sur-
face.

As to the precise apparent magnitude of an object seen after this manner, it is such that the angle it appears under shall be equal to that which the image of the same object would appear under were we to suppose it seen from the same place: that is, the apparent object (for such we must call it to distinguish it from the image of the same object) and the image subtend equal angles at the eye.

DEM. Here we must suppose the pupil of the eye to be a point only, because the magnitude of that causes small alteration in the apparent magnitude of the object; as we shall see by and by. Let then the point a represent the pupil, then will the extreme rays that can enter it be Ha and Ka ; the object therefore will appear under the angle HaK , which is equal to its vertical one MaI , under which the image IM would appear were it to be seen from a . Again, if the eye be placed in f , the object appears under the angle GfO equal to IfM , which the image subtends at the same place, and therefore the apparent object and image of it subtend equal angles at the eye. $\mathcal{Q}$. *E. D.*

Now if we suppose the pupil to have any sensible magnitude, such, suppose, that its diameter may be ab ; then the object seen by the eye in that situation will appear under the angle HXL , which is larger than the angle HaK , under which it appeared before; because the angle at X is nearer than the angle at a , to the line IM , which is a subtense common to them both.

From this proposition it follows, that, were the eye close to the surface at K , the real and apparent object would be seen under equal angles (for the real object appears from that place under the same angle that the image does, as will be shown at the end of this section): therefore, when the eye is nearer to the image than that point, the image will subtend a larger angle at it than the object does; and consequently, since the image and apparent object subtend equal angles at the eye, the apparent object must necessarily be seen under a larger angle than the object itself, wherever the eye be placed, between the surface and the image.

As each point in the representation of an object made by reflection is situated somewhere in a right line that passes through its correspondent point in the object, and is perpendicular to the reflecting surface, as was shown in the beginning of this section; we may from hence deduce a most easy and expeditious method of determining both the magnitude and situation of the image in all cases whatever. Thus,

Through the extremities of the object AB and the centre C (fig. 17, 18, or 19.) draw the lines AC BC , and produce them as the case requires; these lines will be perpendicular to the reflecting surface, and therefore the extremities of the image will fall upon them. Through F the middle point of the object and the centre, draw the line FC , and produce it till it passes through the reflecting surface; this will also be perpendicular to the surface. Through G , the point where this line cuts the surface, draw the lines AG and BG , and produce them this way or that, till they cross the former perpendiculars; and where they cross, there I and M the extremities of the image will fall. For supposing AG to be a ray proceeding from the point A and falling upon G , it will be reflected to B ; because FA is equal to FB , and FG is perpendicular to the reflecting surface; and therefore the representation of the point A will be in BG produced as well as in AC ; consequently it will fall on the point I , where they cross each other. Likewise the ray BG will for the same reason be reflected to A ; and therefore the representation of the point B will be in AG produced, as well as in some part of BC , that is, in M where they cross. From whence the proposition is clear.

If it happens that the lines will not cross which way soever they are produced, as in (fig. 20.), then is the object in the focus of parallel rays of that surface, and has no image formed in any place whatever. For in this case the rays AH , AG , flowing from the point A , become parallel after reflection in the lines HC , GB , and therefore do not flow as to or from any point: in like manner, rays flowing from B are reflected into the parallel lines KB and GA ; so that no representation can be formed by such reflection.

From hence we learn another circumstance relating to the magnitude of the image made by reflection; viz. that it subtends the same angle at the vertex of the reflecting surface that the object does. This appears by inspection of the 17th, 18th, or 19th figure, in each of which the angle IGM , which the image subtends at G the vertex of the reflecting surface, is equal to the angle AGB , which the object subtends at the same place; for in the two first of those figures they are vertical, in the third they are the same. And,

Farther, the angle ICM , which the image subtends at the centre, is also equal to the angle ACB which the object subtends at the same place; for in the two first figures they are the same, in the last they are vertical to each other.

From whence it is evident, that the object and its image are to each other in diameter, either as their respective distances from the vertex of the reflecting surface, or as their distances from the centre of the same.

Light dif-
ferently
refrangi-
ble.

Plate
CCCLIX.

IV. As objects are multiplied by being seen thro' transparent media, whose surfaces are properly disposed, so they may also by reflecting surfaces. Thus,

1. If two reflecting surfaces be disposed at right angles, as the surfaces AB, BC, (fig. 21.), an object at D may be seen by an eye at E, after one reflection at F, in the line EF produced; after two reflections, the first at G, the second at H, in the line EH produced; and also, after one reflection made at A, in the line EA produced.

2. If the surfaces be parallel, as AB, CD, (fig. 22.), and the object be placed at E and the eye at F, the object will appear multiplied an infinite number of times: thus, it may be seen in the line FG produced, after one reflection at G; in the line FH produced, after two reflections, the first at I, the second at H; and also in FP produced, after several successive reflections of the ray EL, at the points L, M, N, O, and P: and so on *in infinitum*. But the greater the number of reflections are, the weaker their representation will be.

SECT. IV. Of the different Refrangibility of Light.

As this property of light solves a great number of the phenomena which could not be understood by former opticians, we shall give an account of it in the words of Sir Isaac Newton, who first discovered it; especially as his account is much more full, clear, and perspicuous, than those of succeeding writers.

Plate
CCCLX.

"In a very dark chamber, at a round hole F (fig. 1.), about one third of an inch broad, made in the shut of a window, I placed a glass prism ABC, whereby the beam of the sun's light, SF, which came in at that hole, might be refracted upwards, toward the opposite wall of the chamber, and there form a coloured image of the sun, represented at PT. The axis of the prism (that is, the line passing through the middle of the prism, from one end of it to the other end, parallel to the edge of the refracting angle) was in this and the following experiments perpendicular to the incident rays. About this axis I turned the prism slowly, and saw the refracted light on the wall, or coloured image of the sun, first to descend, and then to ascend. Between the descent and ascent, when the image seemed stationary, I stopped the prism and fixed it in that posture.

"Then I let the refracted light fall perpendicularly upon a sheet of white paper, MN, placed at the opposite wall of the chamber, and observed the figure and dimensions of the solar image, PT, formed on the paper by that light. This image was oblong, and not oval, but terminated by two rectilinear and parallel sides and two semicircular ends. On its sides it was bounded pretty distinctly; but on its ends very confusedly and indistinctly, the light there decaying and vanishing by degrees. At the distance of $18\frac{1}{2}$ feet from the prism the breadth of the image was about $2\frac{1}{8}$ inches, but its length was about $10\frac{1}{4}$ inches, and the length of its rectilinear sides about eight inches; and ACB, the refracting angle of the prism, whereby so great a length was made, was 64 degrees. With a less angle the length of the image was less, the breadth remaining the same. It is farther to be observed, that the rays went on in straight lines from the prism to the image,

and therefore at their going out of the prism had all that inclination to one another from which the length of the image proceeded. This image PT was coloured, and the more eminent colours lay in this order from the bottom at T to the top at P; red, orange, yellow, green, blue, indigo, violet; together with all their intermediate degrees in a continual succession perpetually varying."

Our author concludes from this experiment, and many more to be mentioned hereafter, "that the light of the sun consists of a mixture of several sorts of coloured rays, some of which at equal incidences are more refracted than others, and therefore are called *more refrangible*. The red at T, being nearest to the place Y, where the rays of the sun would go directly if the prism was taken away, is the least refracted of all the rays; and the orange, yellow, green, blue, indigo, and violet, are continually more and more refracted, as they are more and more diverted from the course of the direct light. For by mathematical reasoning he has proved, that when the prism is fixed in the posture above-mentioned, so that the place of the image shall be the lowest possible, or at the limit between its descent and ascent, the figure of the image ought then to be round like the spot at Y, if all the rays that tended to it were equally refracted. Therefore, seeing by experience it is found that this image is not round, but about five times longer than broad, it follows that all the rays are not equally refracted. And this conclusion is farther confirmed by the following experiments.

"In the sun-beam SF (fig. 2.), which was propagated into the room thro' the hole in the window-shut EG, at the distance of some feet from the hole, I held the prism ABC in such a posture, that its axis might be perpendicular to that beam: then I looked through the prism upon the hole F, and turning the prism to and fro about its axis to make the image *pt* of the hole ascend and descend, when between its two contrary motions it seemed stationary, I stopped the prism; in this situation of the prism, viewing through it the said hole F, I observed the length of its refracted image *pt* to be many times greater than its breadth; and that the most refracted part thereof appeared violet at *p*; the least refracted red, at *t*; and the middle parts indigo, blue, green, yellow, and orange, in order. The same thing happened when I removed the prism out of the sun's light, and looked through it upon the hole shining by the light of the clouds beyond it. And yet if the refractions of all the rays were equal according to one certain proportion of the sines of incidence and refraction, as is vulgarly supposed, the refracted image ought to have appeared round, by the mathematical demonstration above-mentioned. So then by these two experiments it appears, that in equal incidences there is a considerable inequality of refractions."

For the discovery of this fundamental property of light, which has opened the whole mystery of colours, we see our author was not only beholden to the experiments themselves, which many others had made before him, but also to his skill in geometry; which was absolutely necessary to determine what the figure of the refracted image ought to be upon the old principle of an equal refraction of all the rays: but ha-

OPTICS.

Plate CCCLIX.

Fig. 1.

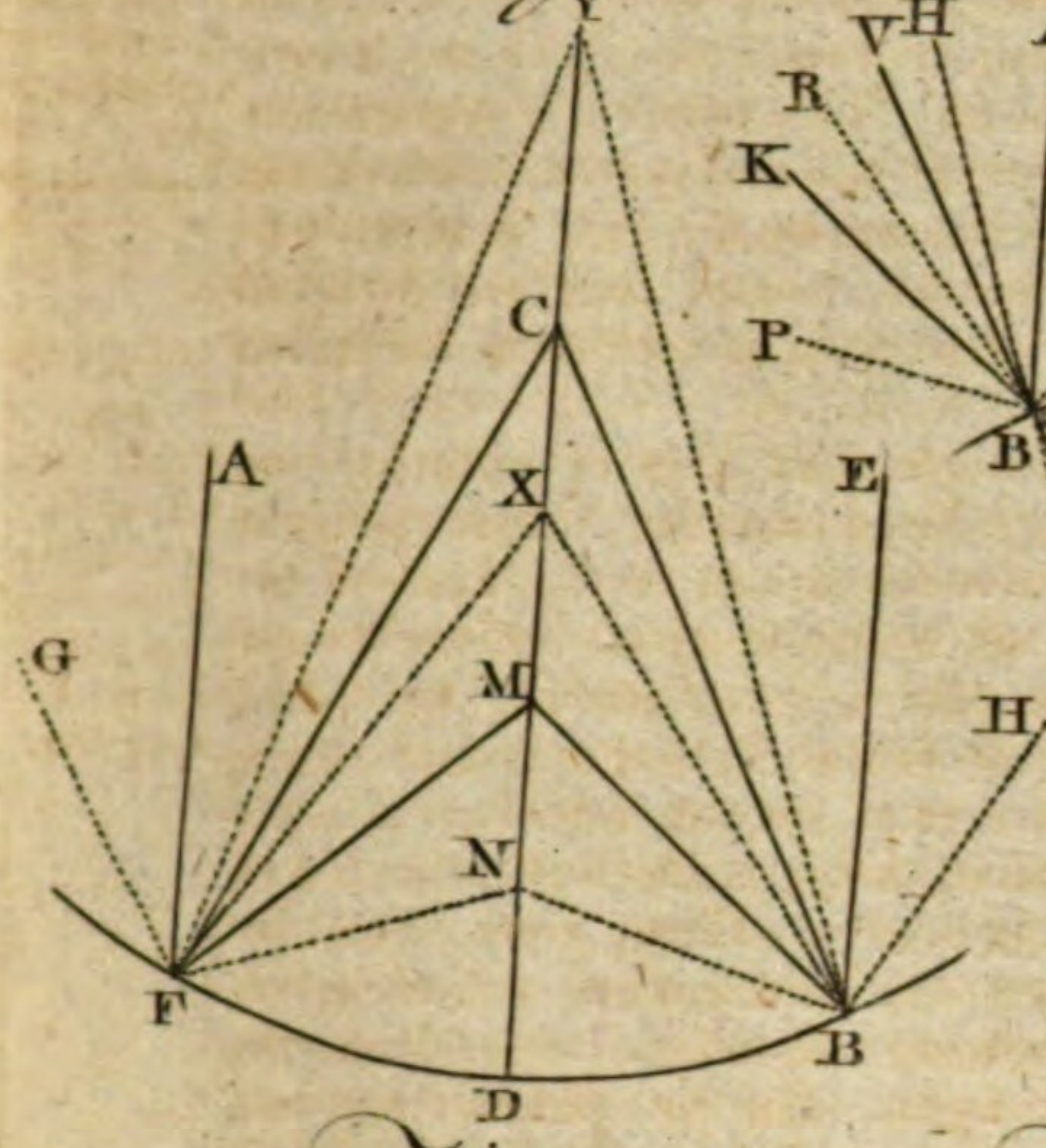


Fig. 2.

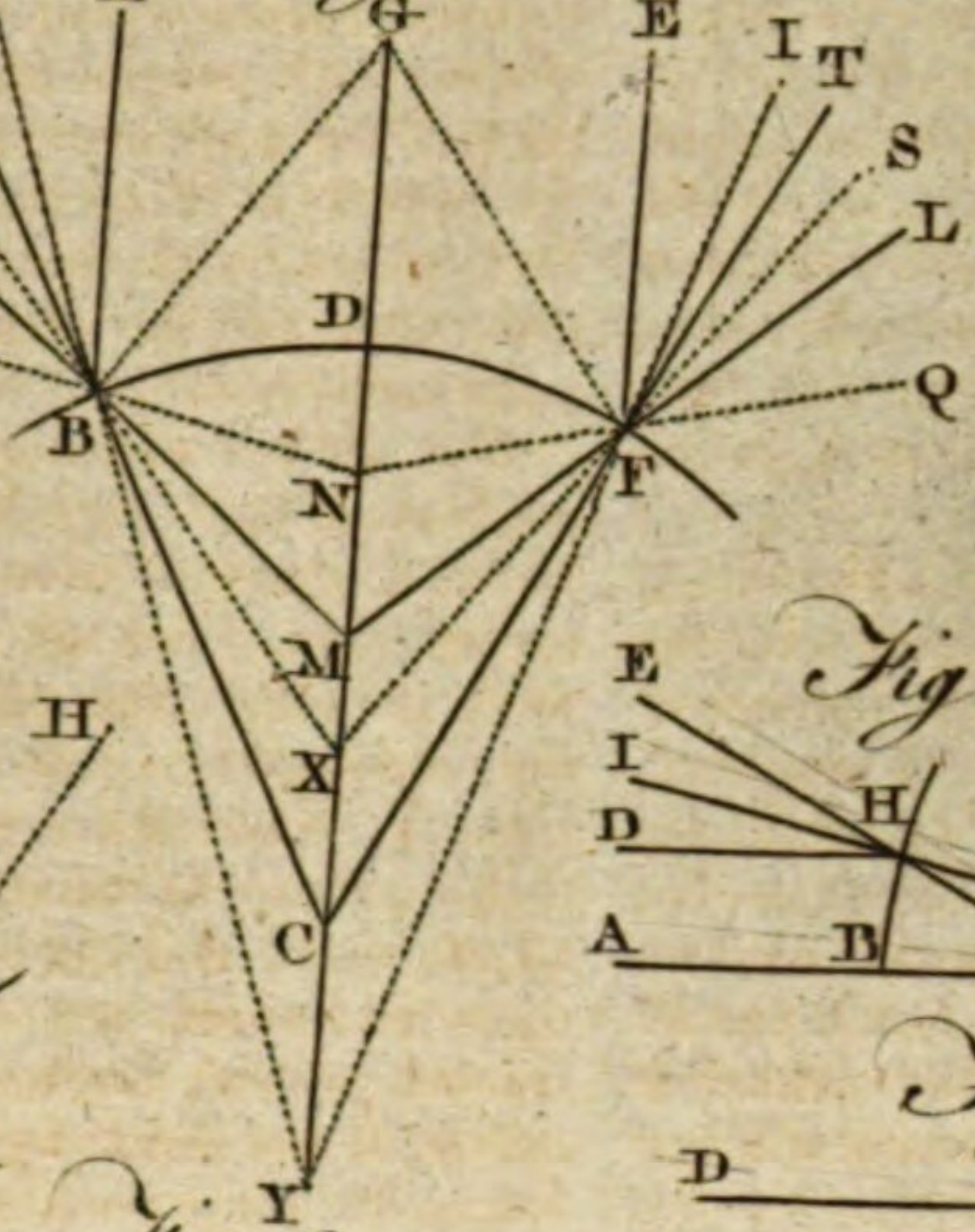


Fig. 3.

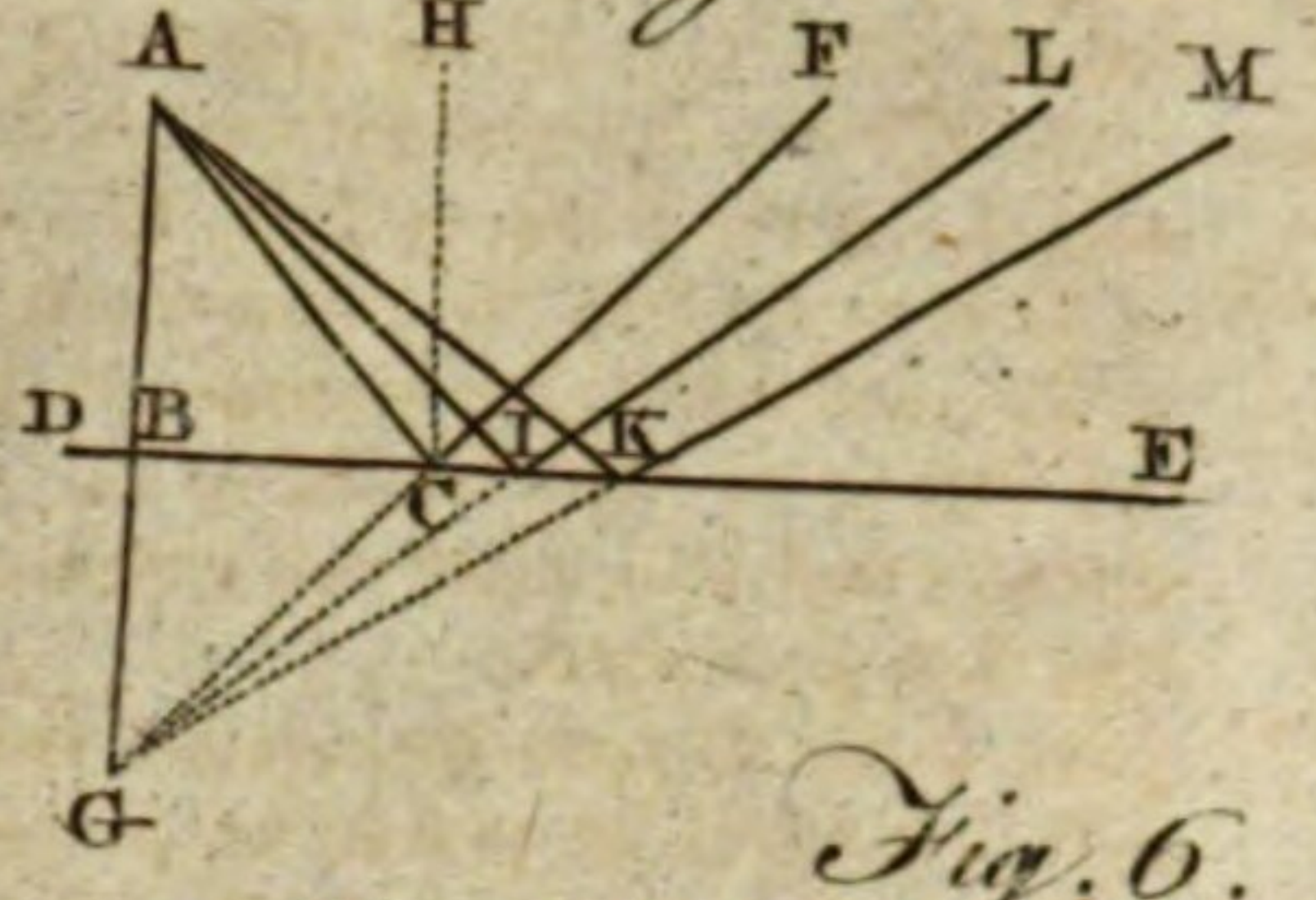


Fig. 4.

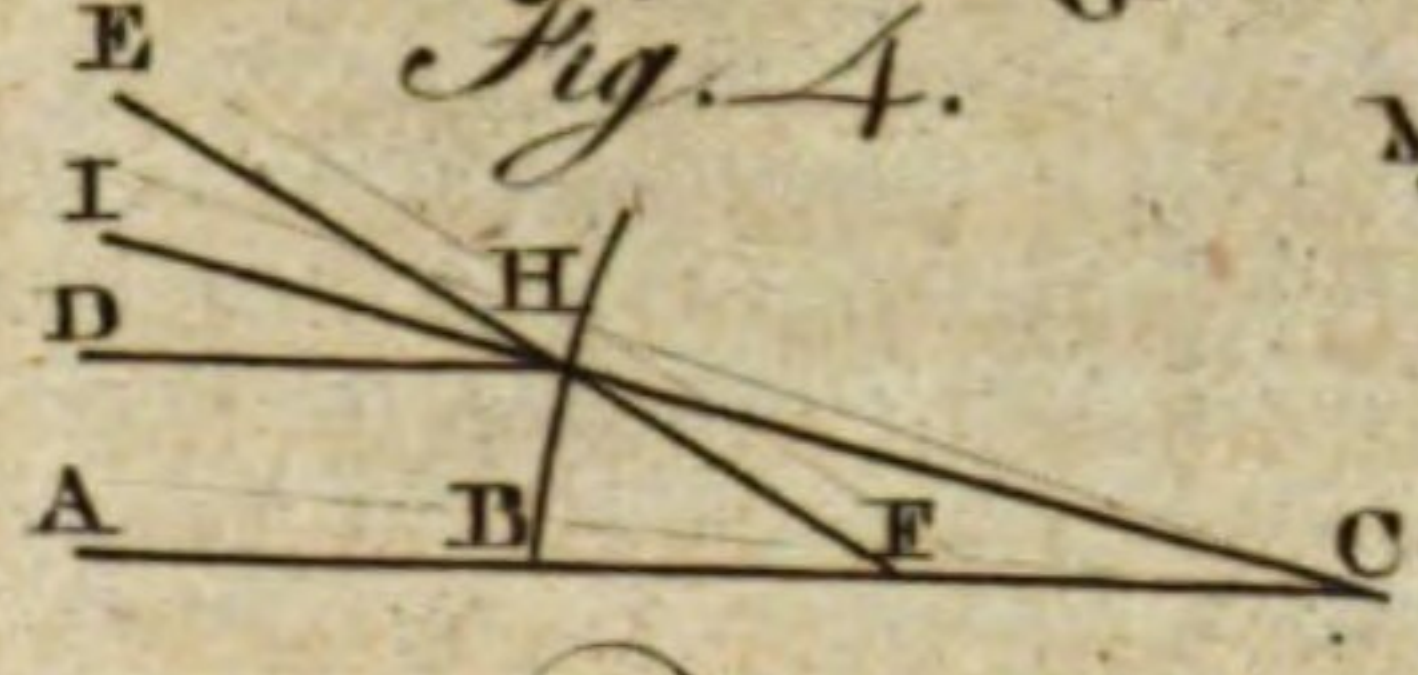


Fig. 6.

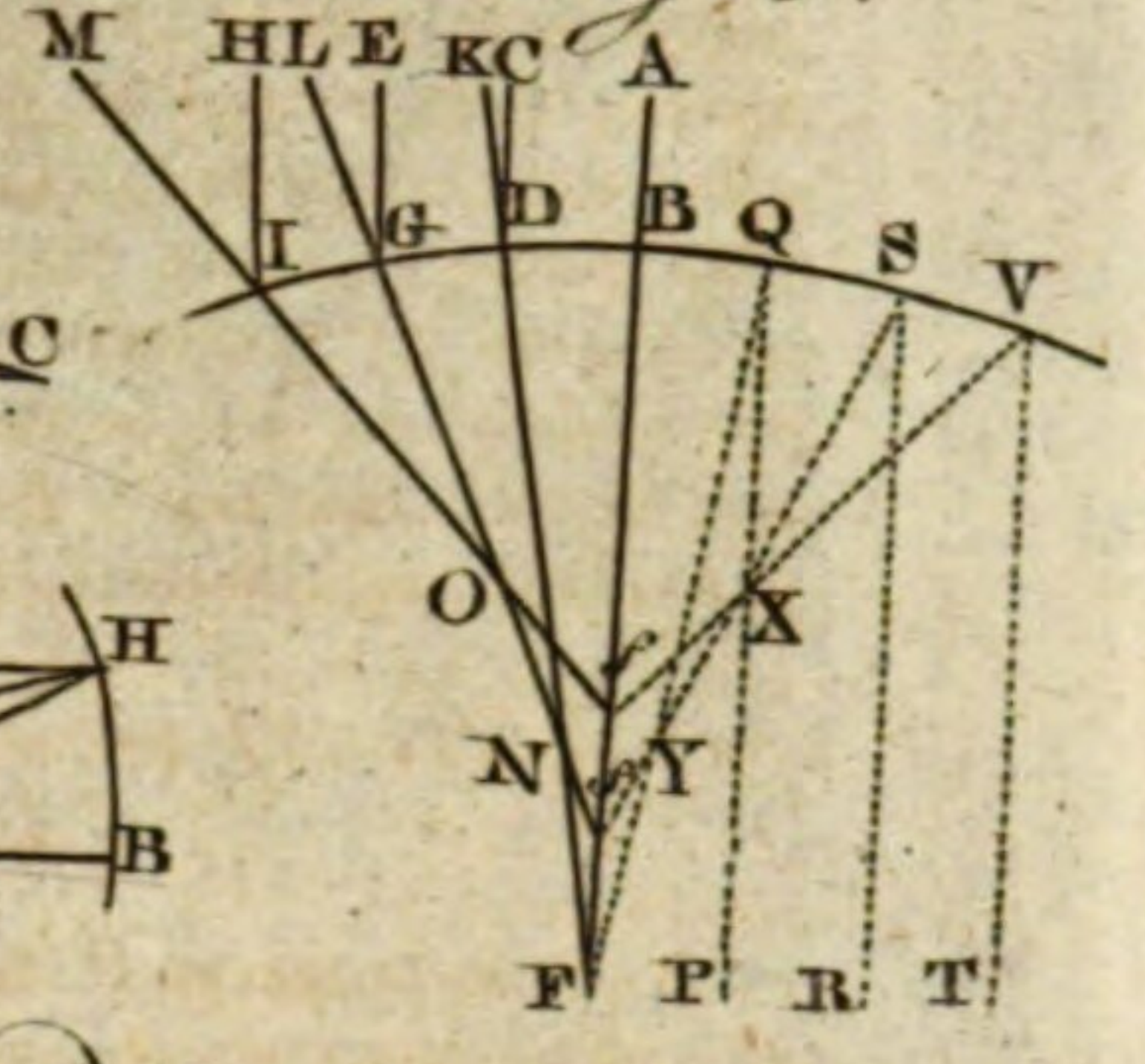


Fig. 5.

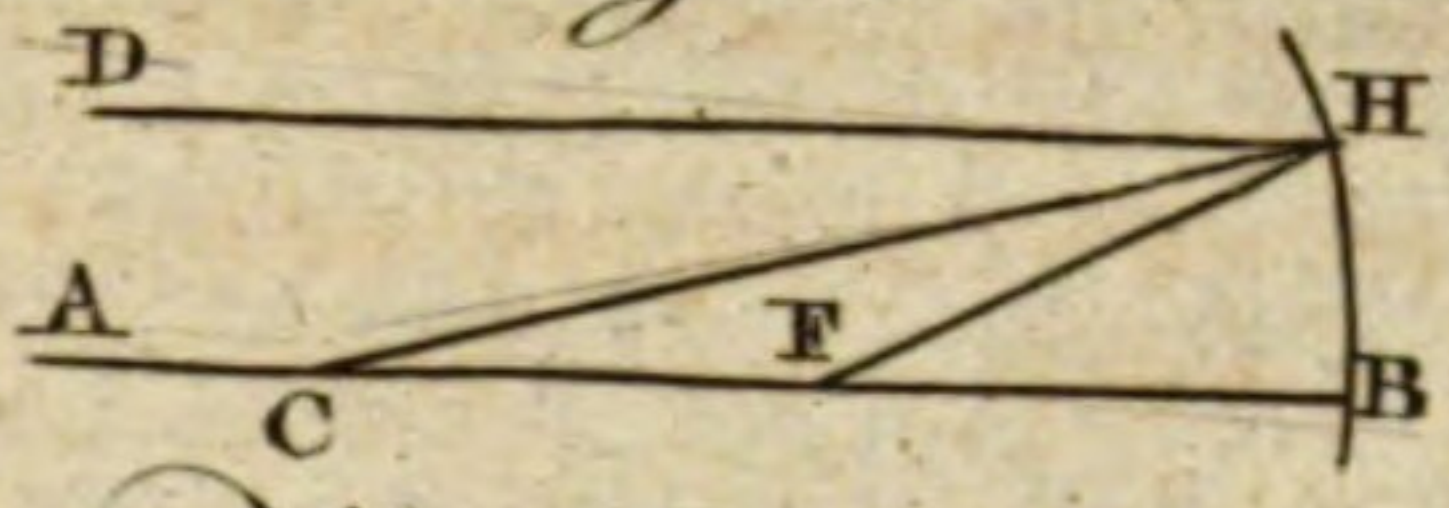


Fig. 7.

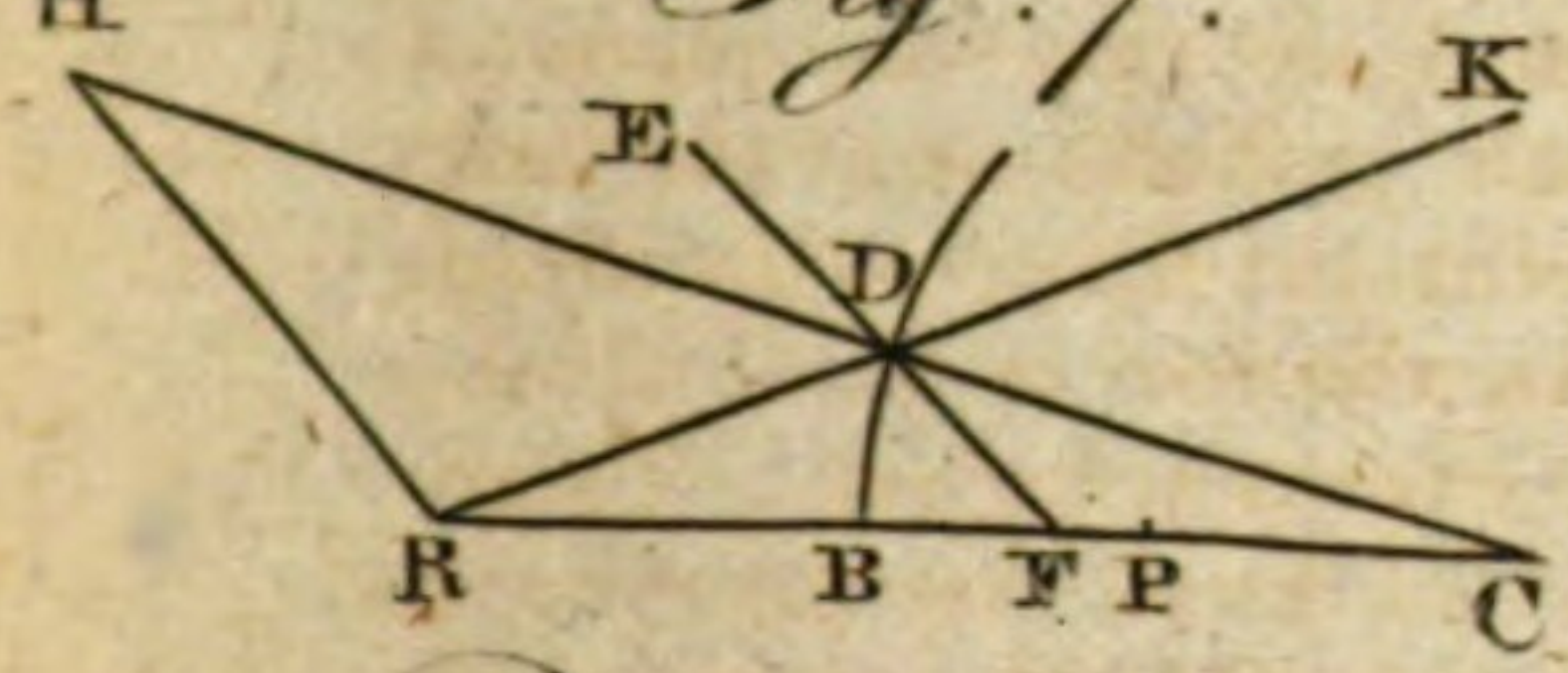


Fig. 9.

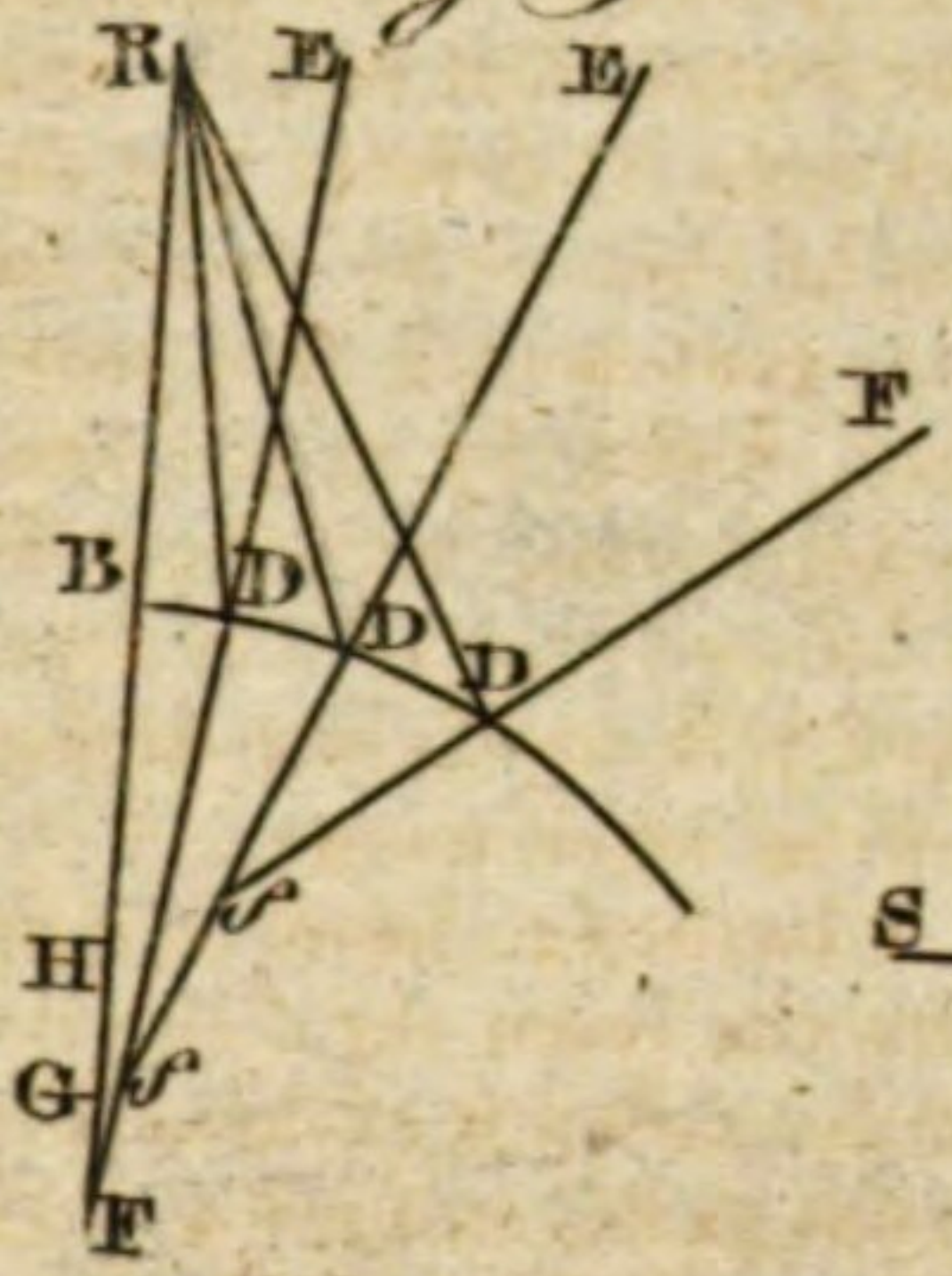


Fig. 10.

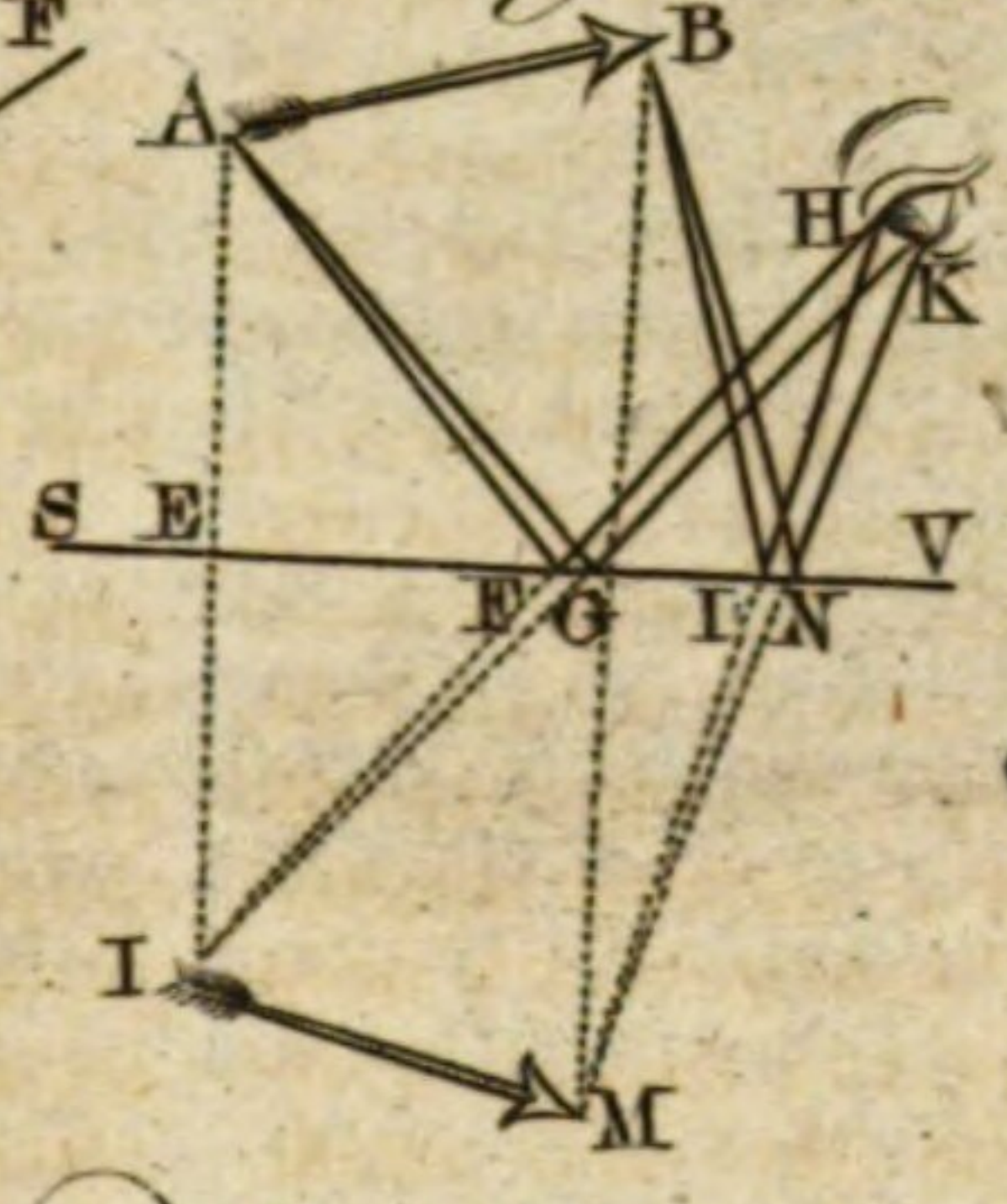


Fig. 11.

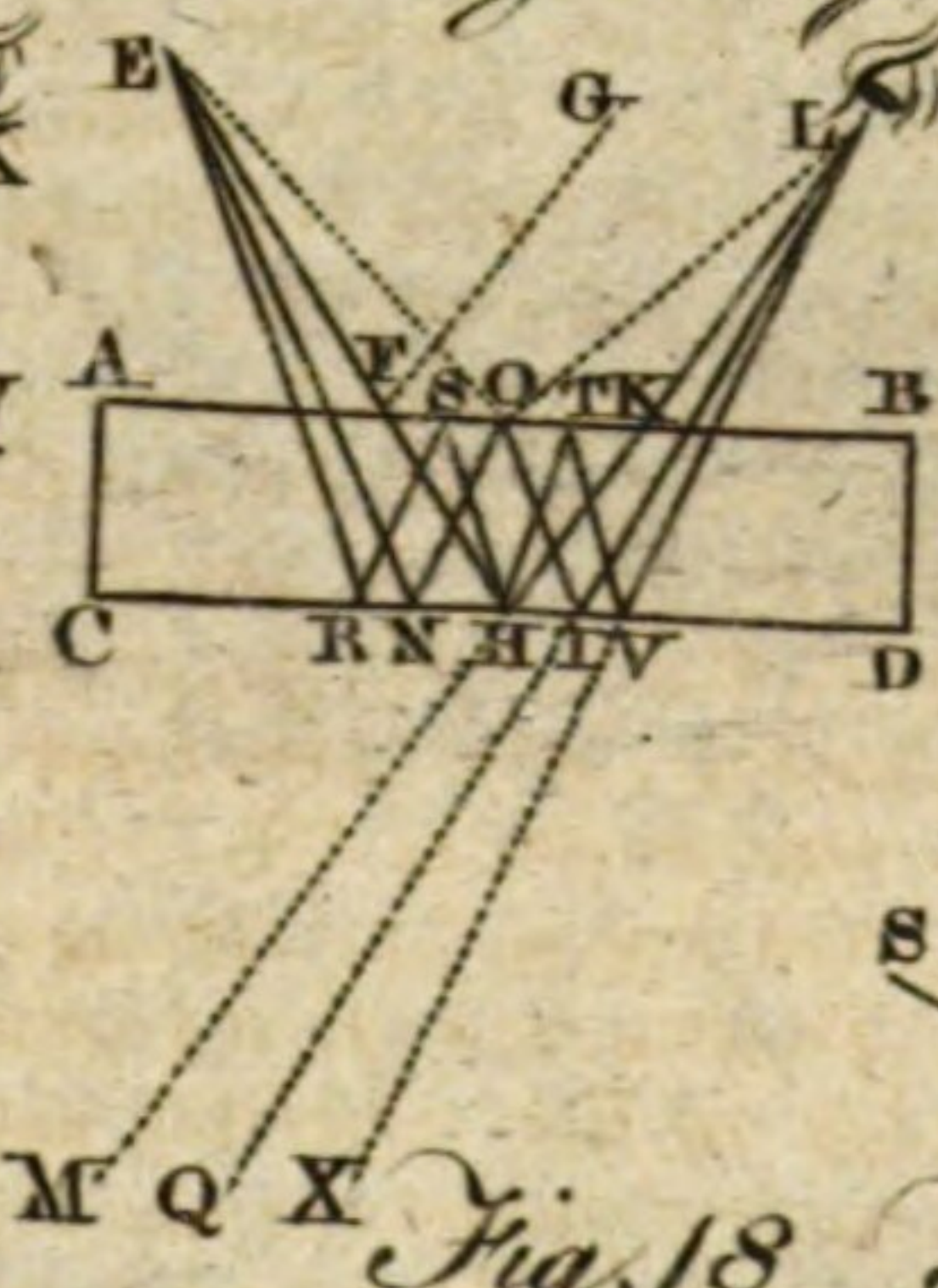


Fig. 19.

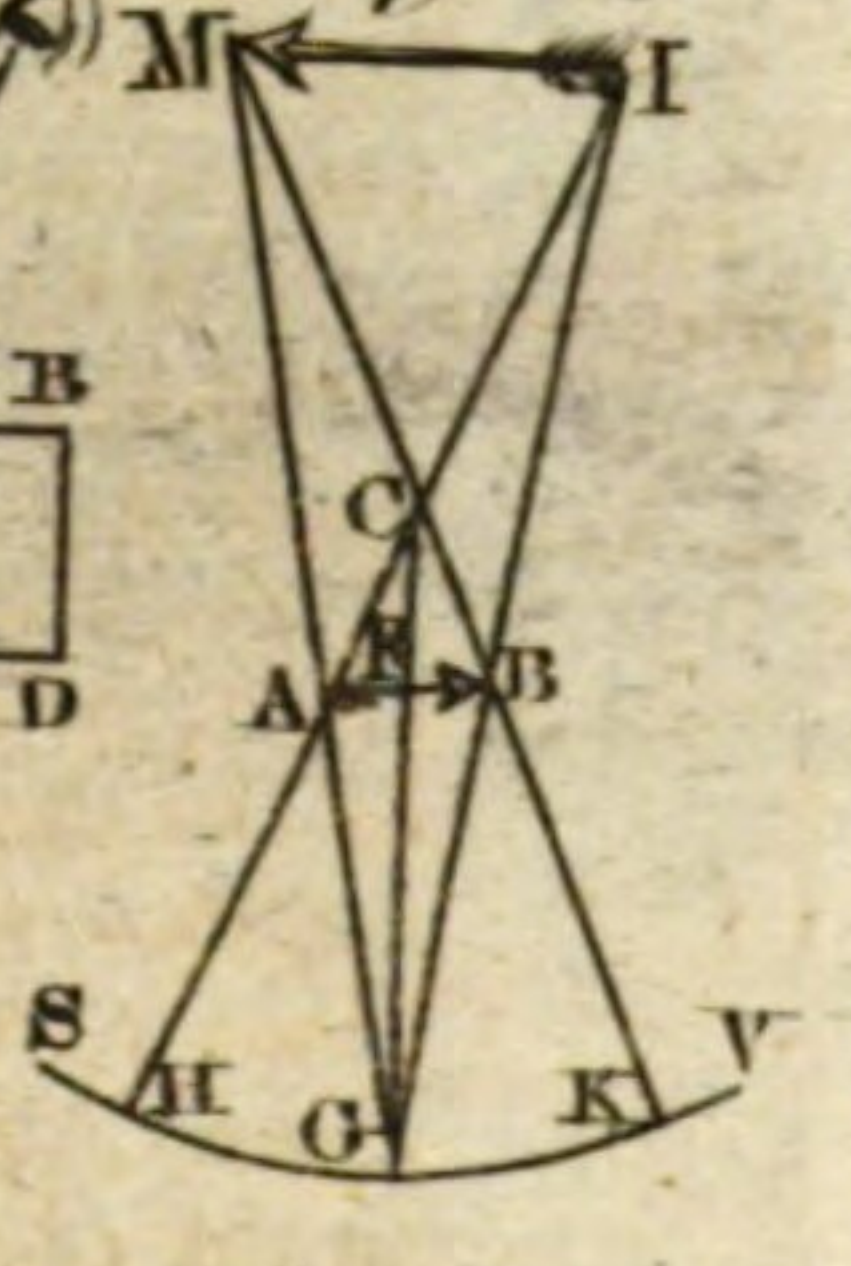


Fig. 8.

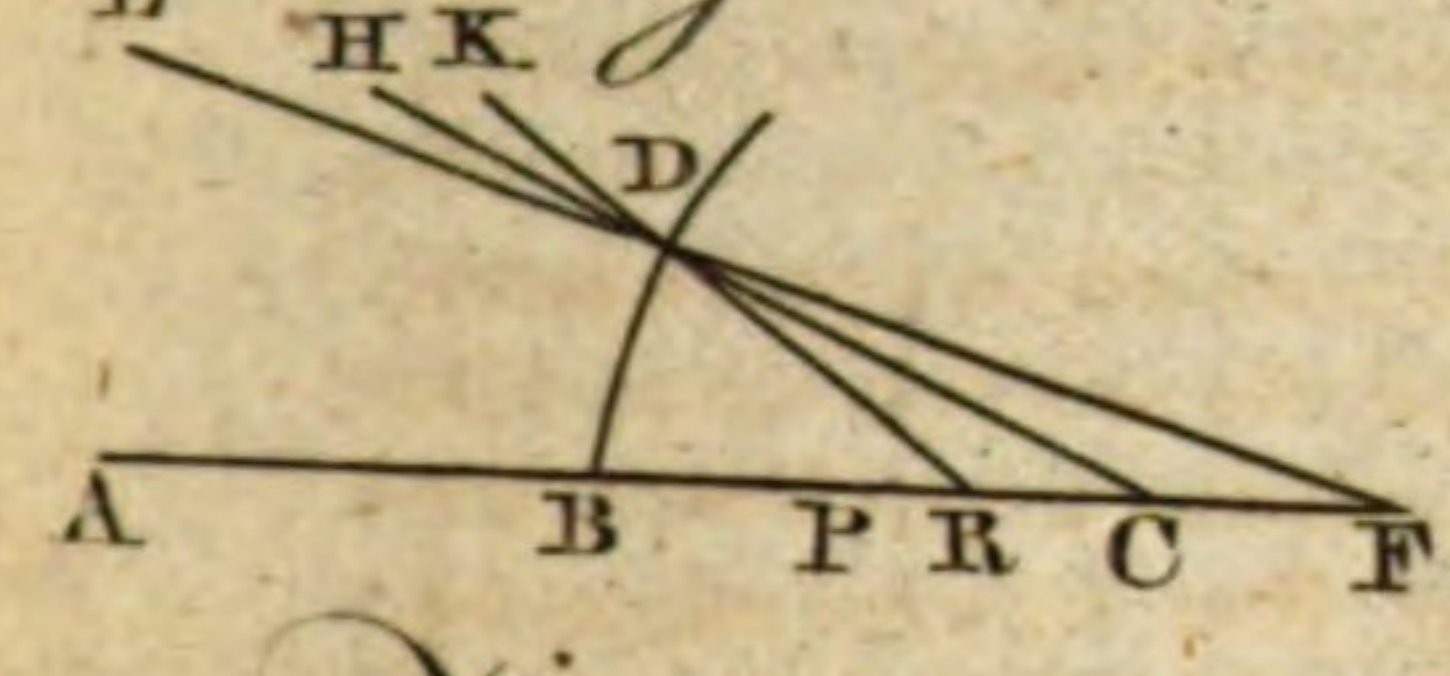


Fig. 12.



Fig. 14.

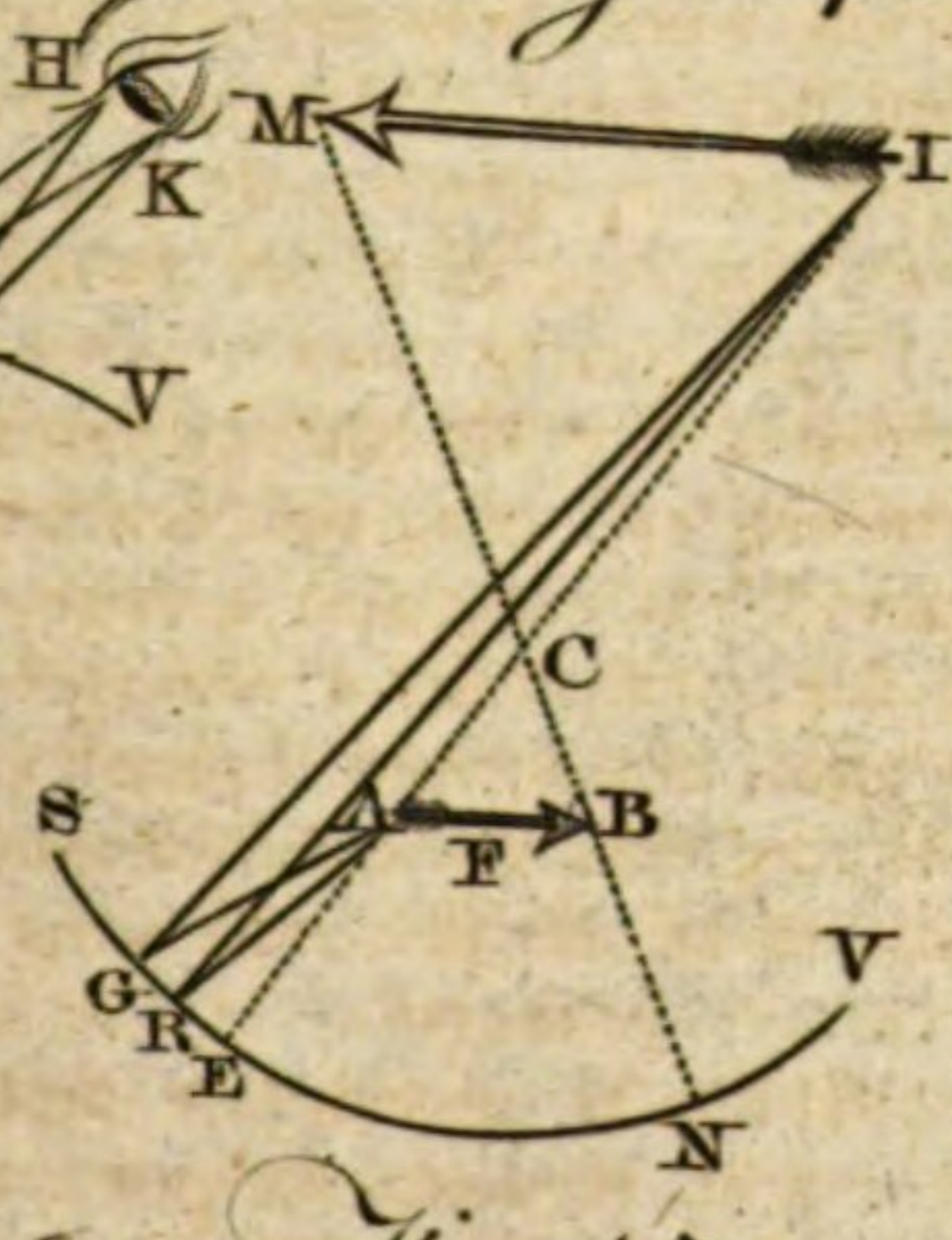


Fig. 16.

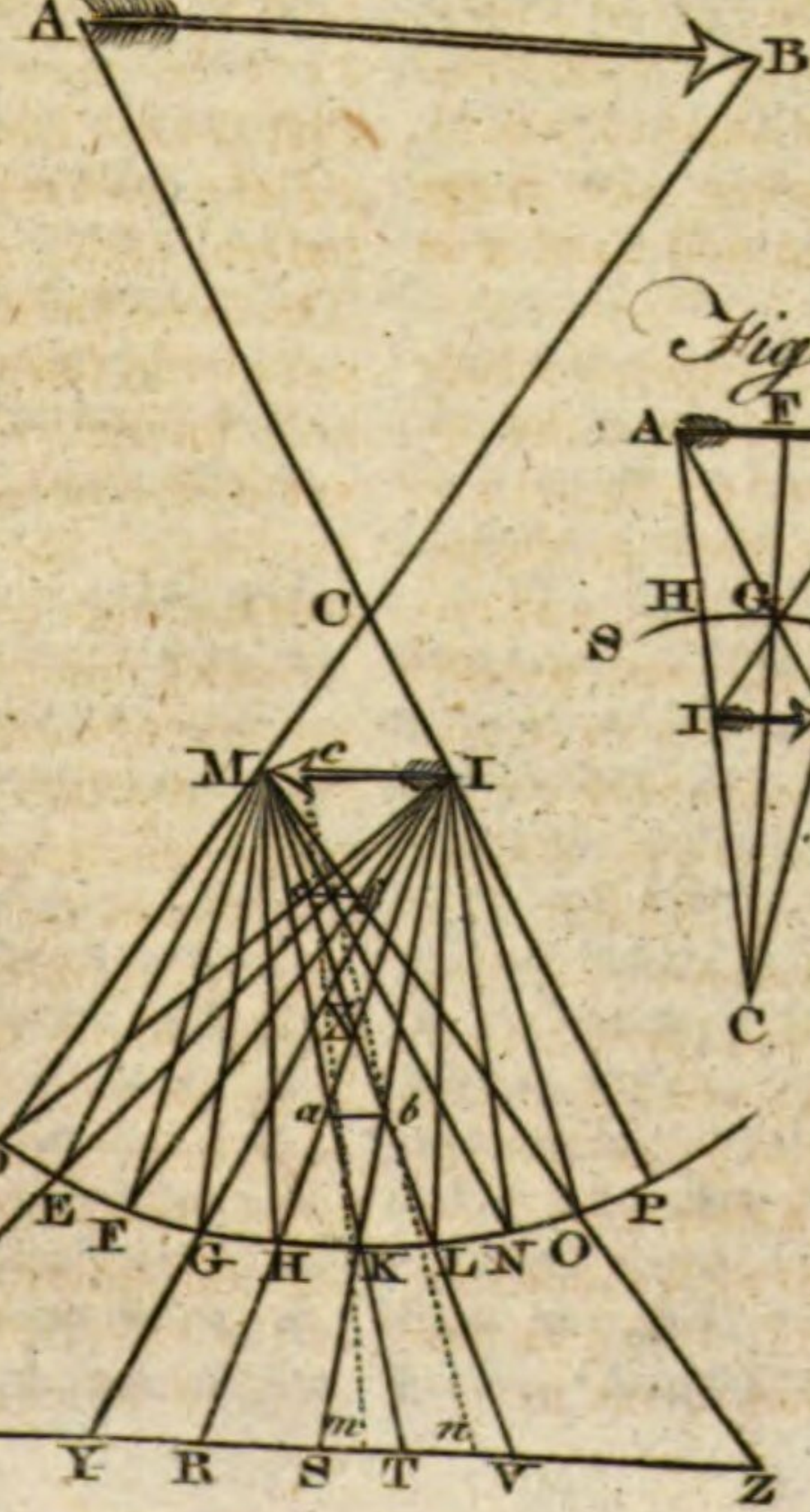


Fig. 18.

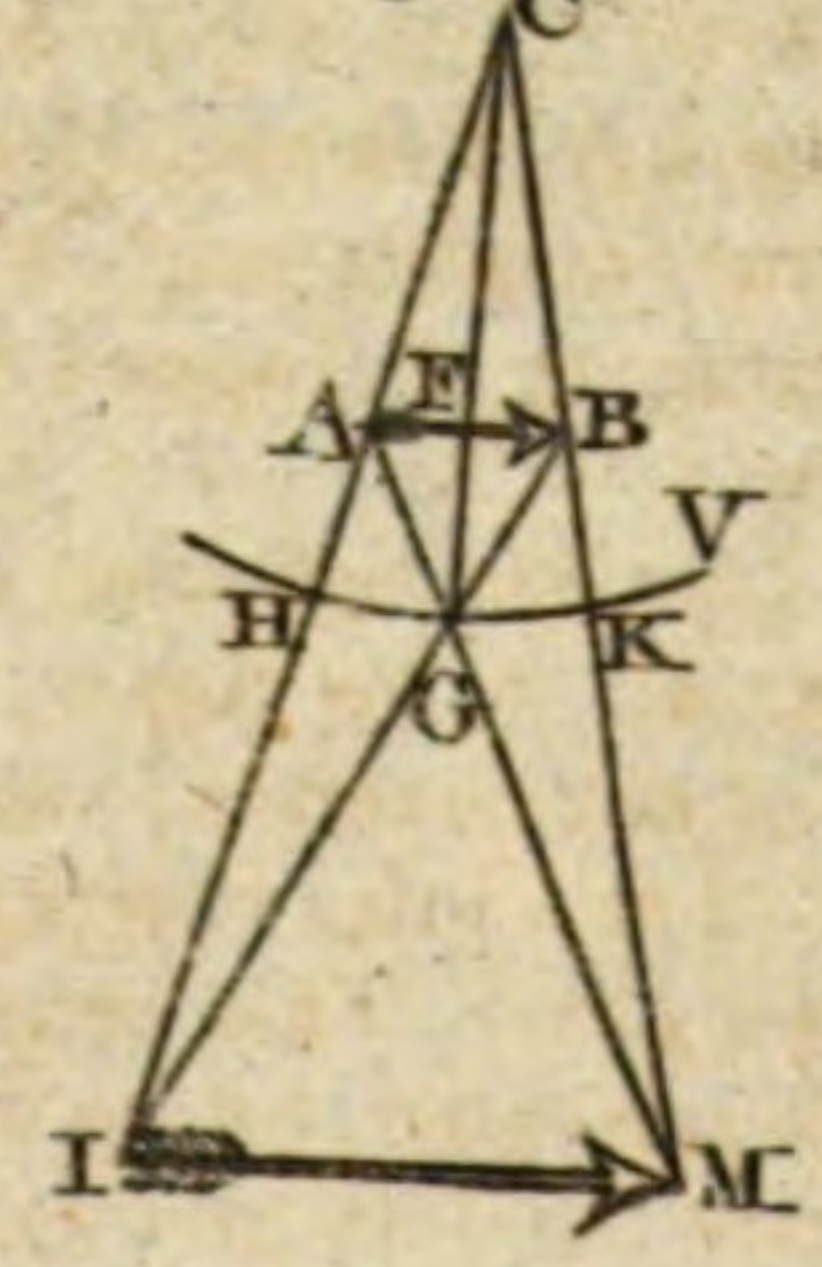


Fig. 20.

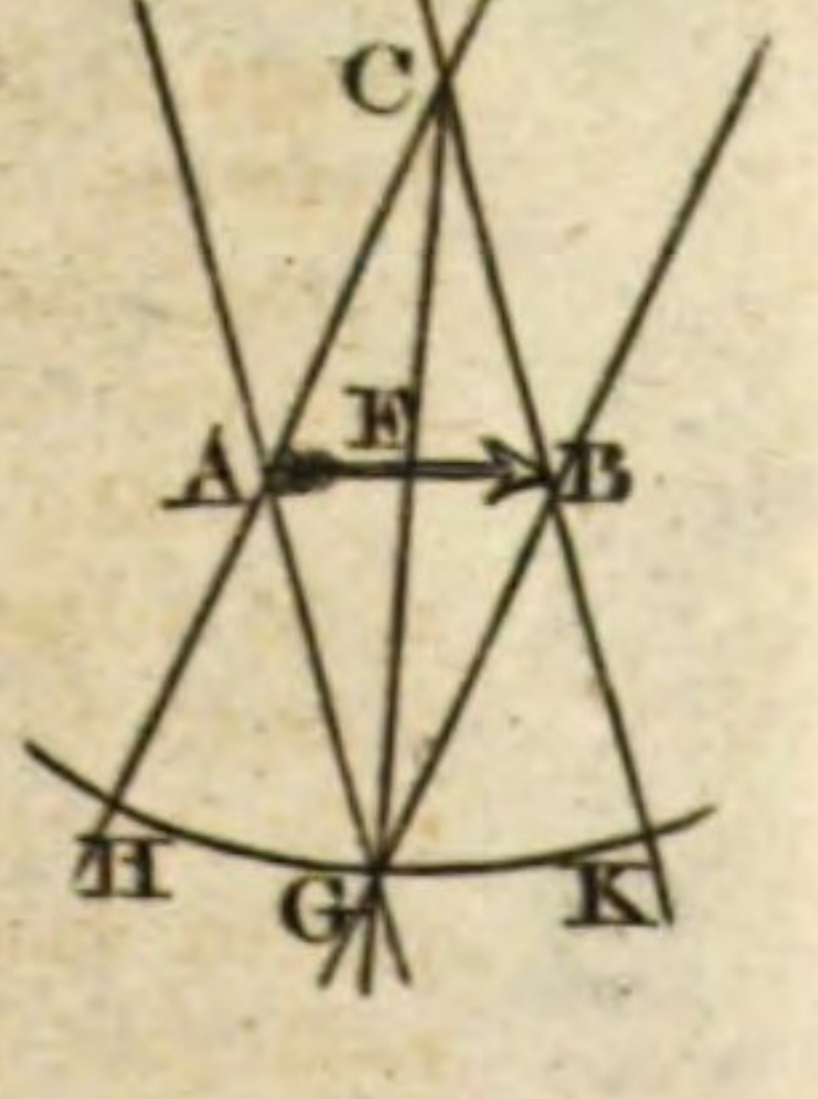


Fig. 13.

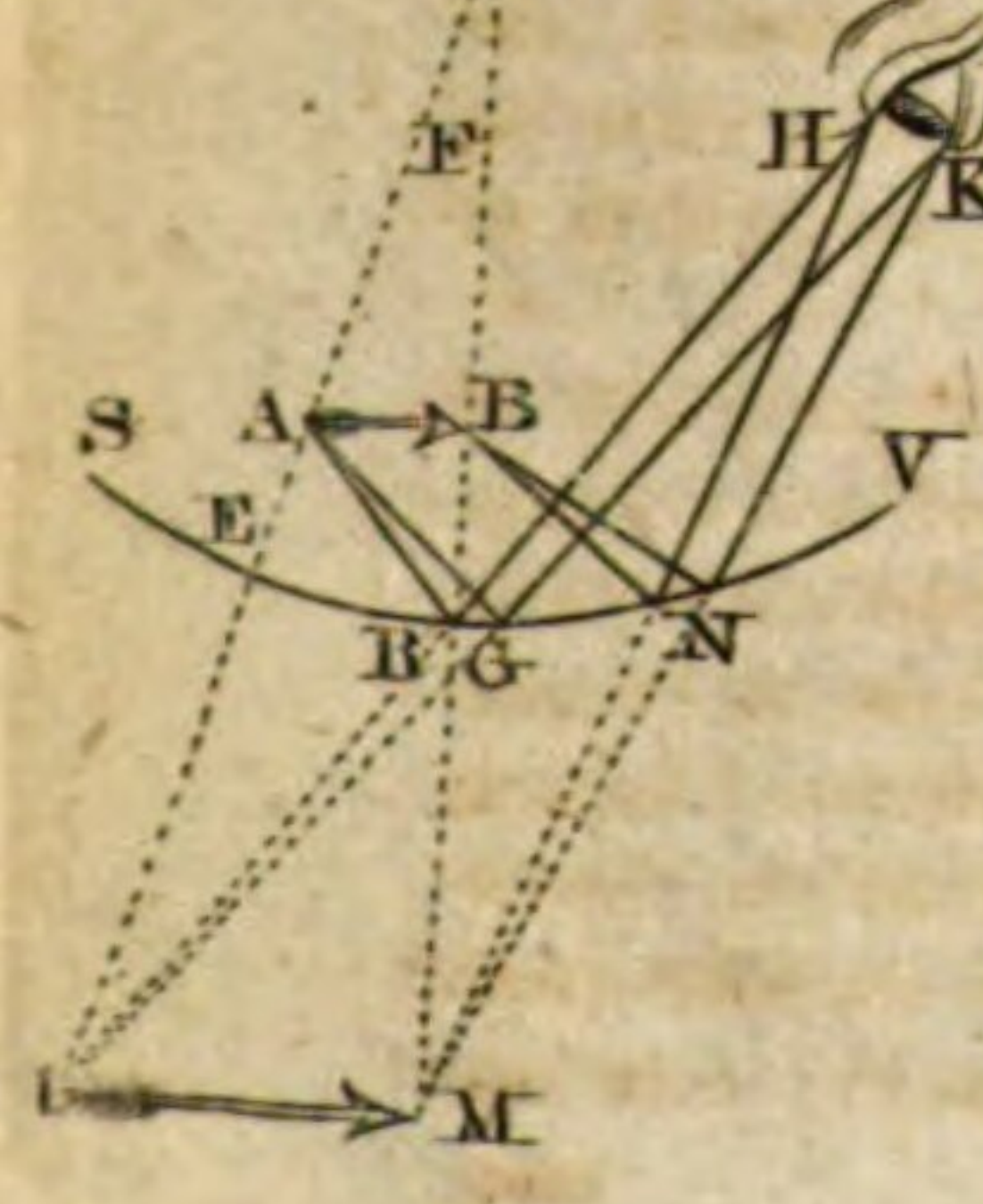


Fig. 15.

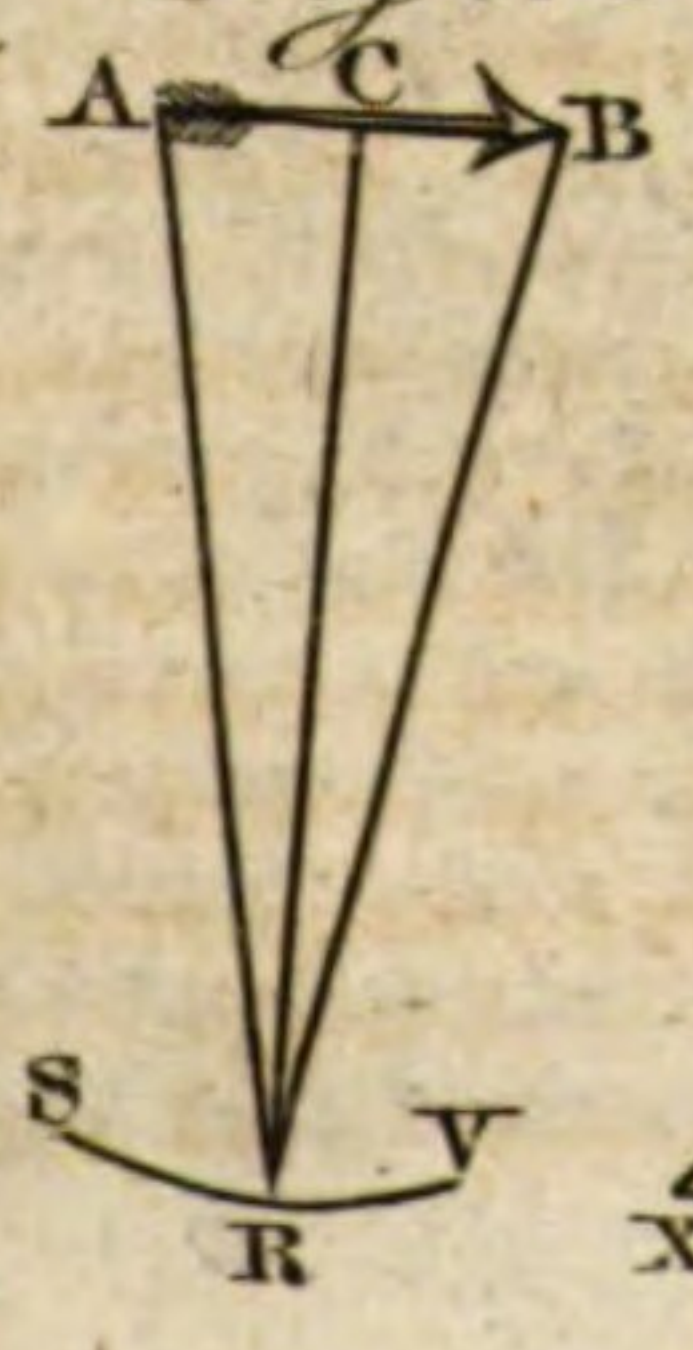


Fig. 17.

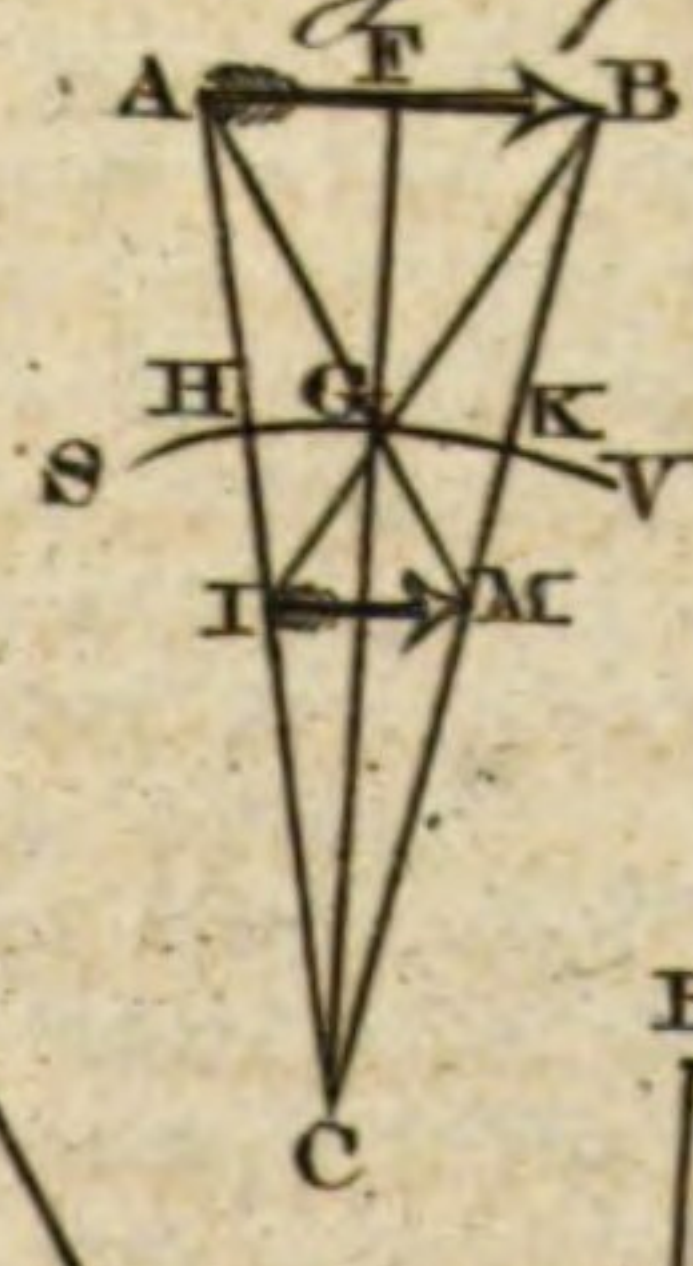


Fig. 21.

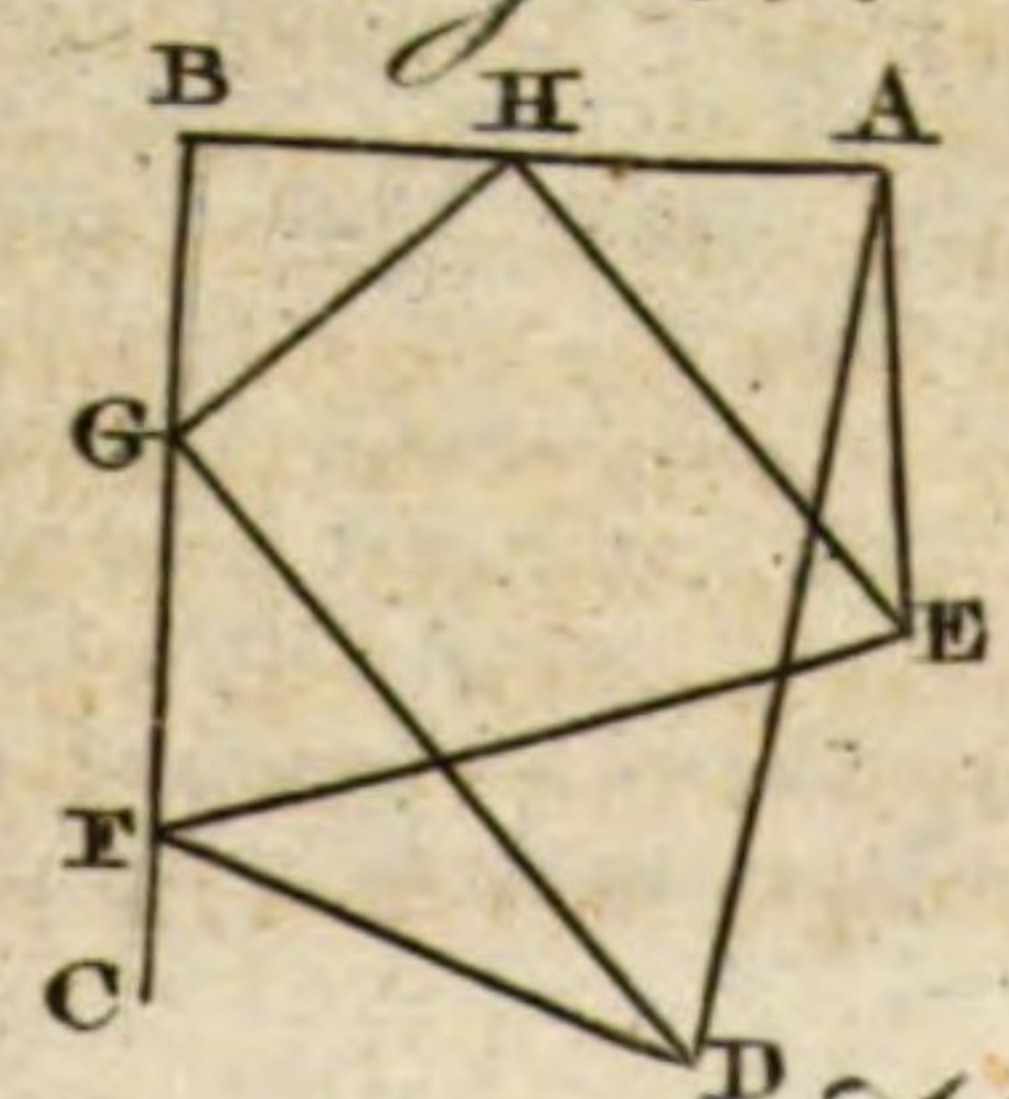
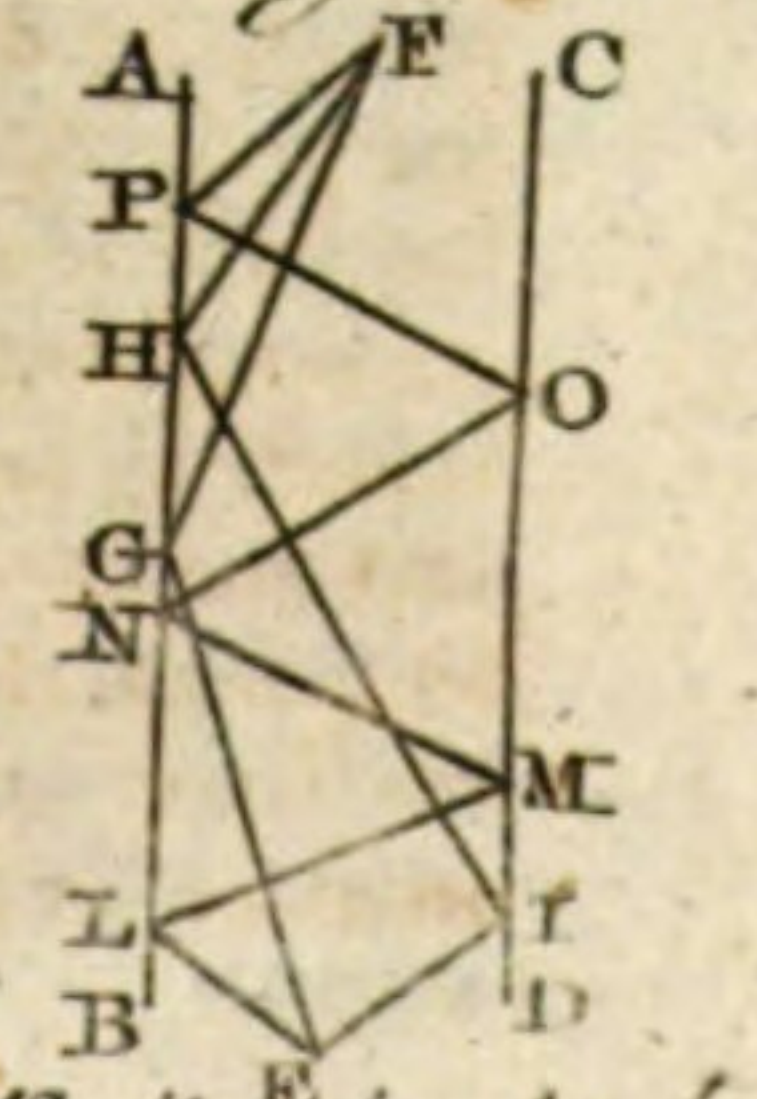
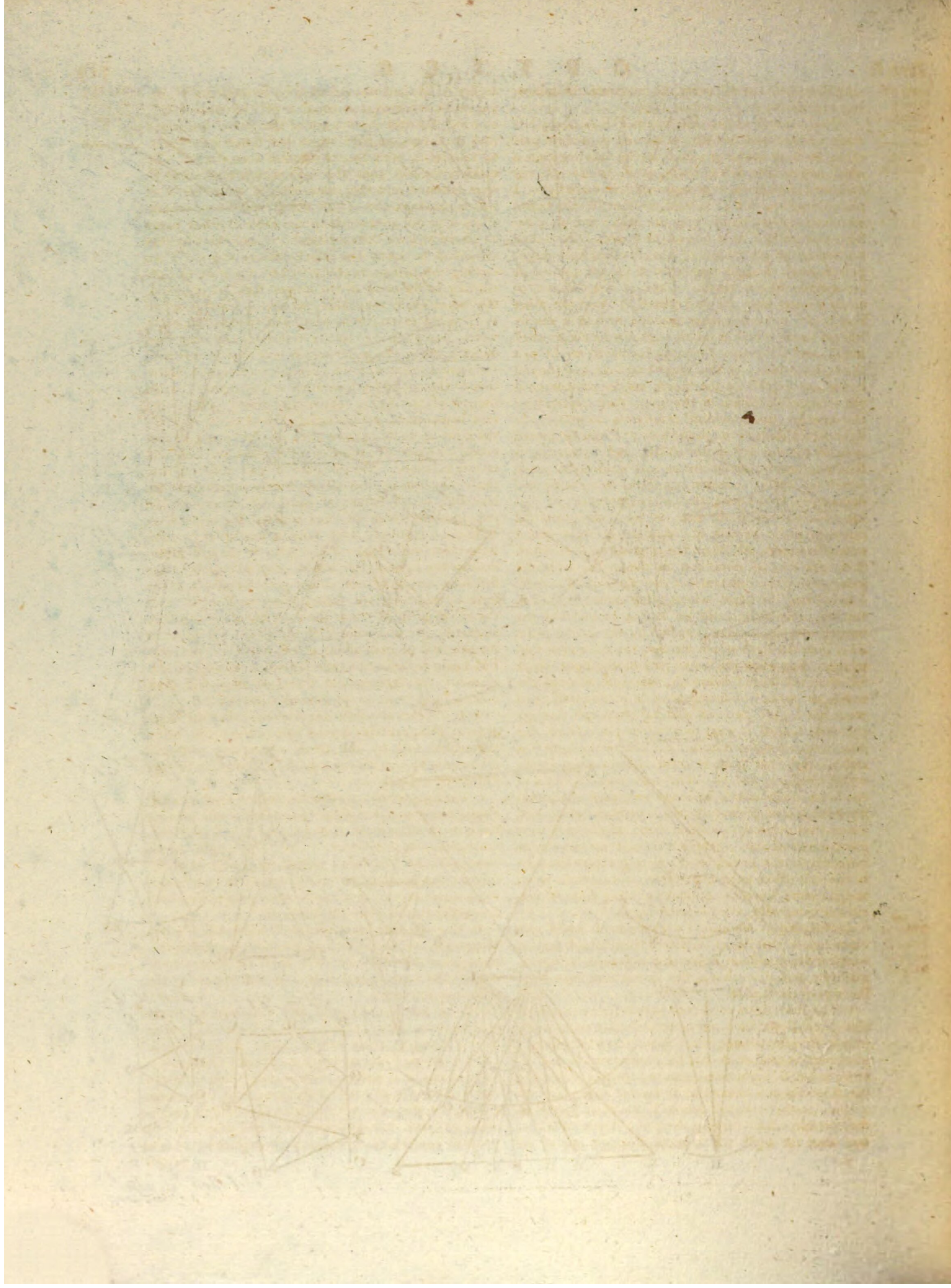


Fig. 22.



A Bell Sculp.



Light dif-
ferently
refrangible.

Plate
CCCLX.

ving thus made the discovery, he contrived the following experiment to prove it at sight.

"In the middle of two thin boards, *DE de*, (fig. 3.), I made a round hole in each, at *G* and *g*, a third part of an inch in diameter; and in the window-shut a much larger hole being made, at *F*, to let into my darkened chamber a large beam of the sun's light, I placed a prism, *ABC*, behind the shut in that beam, to refract it towards the opposite wall; and close behind this prism I fixed one of the boards *DE*, in such a manner that the middle of the refracted light might pass through the hole made in it at *G*, and the rest be intercepted by the board. Then at the distance of about 12 feet from the first board, I fixed the other board, *de*, in such manner that the middle of the refracted light, which came through the hole in the first board, and fell upon the opposite wall, might pass through the hole *g* in this other board *de*, and the rest being intercepted by the board, might paint upon it the coloured spectrum of the sun. And close behind this board I fixed another prism *abc*, to refract the light which came through the hole *g*. Then I returned speedily to the first prism *ABC*, and by turning it slowly to and fro about its axis, I caused the image which fell upon the second board *de*, to move up and down upon that board, that all its parts might pass successively through the hole in that board, and fall upon the prism behind it. And in the mean time I noted the places, *M*, *N*, on the opposite wall, to which that light after its refraction in the second prism did pass; and by the difference of the places at *M* and *N*, I found that the light, which being most refracted in the first prism *ABC*, did go to the blue end of the image, was again more refracted by the second prism *abc*, than the light which went to the red end of that image. For when the lower part of the light which fell upon the second board *de*, was cast through the hole *g*, it went to a lower place *M* on the wall; and when the higher part of that light was cast through the same hole *g*, it went to a higher place *N* on the wall; and when any intermediate part of the light was cast through that hole, it went to some place in the wall between *M* and *N*. The unchanged position of the holes in the boards made the incidence of the rays upon the second prism to be the same in all cases. And yet in that common incidence some of the rays were more refracted and others less: and those were more refracted in this prism, which by a greater refraction in the first prism were more turned out of their way; and therefore, for their constancy of being more refracted, are deservedly called *more refrangible*."

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Reflected
light dif-
ferently re-
frangible

Our author shows also, by experiments made with convex glass, that lights (reflected from natural bodies) which differ in colour, differ also in degrees of refrangibility; and that they differ in the same manner as the rays of the sun do.

"The sun's light consists of rays differing in reflexivity, and those rays are more reflexible than others which are more refrangible. A prism, *ABC* (fig. 4.), whose two angles, at its base *BC*, were equal to one another and half right ones, and the third at *A* a right one, I placed in a beam *FM* of the sun's light, let into a dark chamber through a hole *F* one third part of an inch broad. And turning the prism slowly about its axis until the light which went through one of its

angles *ACB*, and was refracted by it to *G* and *H*, began to be reflected into the line *MN* by its base *BC*, at which till then it went out of the glass; I observed that those rays, as *MH*, which had suffered the greatest refraction, were sooner reflected than the rest. To make it evident that the rays which vanished at *H* were reflected into the beam *MN*, I made this beam pass through another prism *VXY*, and being refracted by it to fall afterwards upon a sheet of white paper *pt* placed at some distance behind it, and there by that refraction to paint the usual colours at *pt*. Then causing the first prism to be turned about its axis according to the order of the letters *ABC*, I observed, that when those rays *MH*, which in this prism had suffered the greatest refraction, and appeared blue and violet, began to be totally reflected, the blue and violet light on the paper which was most refracted in the second prism received a sensible increase at *p*, above that of the red and yellow at *t*: and afterwards, when the rest of the light, which was green, yellow, and red, began to be totally reflected and vanished at *G*, the light of those colours at *t*, on the paper *pt*, received as great an increase as the violet and blue had received before. Which puts it past dispute, that those rays became first of all totally reflected at the base *BC*, which before at equal incidences with the rest upon the base *BC* had suffered the greatest refraction. I do not here take notice of any refractions made in the sides *AC*, *AB*, of the first prism, because the light enters almost perpendicularly at the first side, and goes out almost perpendicularly at the second; and therefore suffers none, or so little, that the angles of incidence at the base *BC* are not sensibly altered by it; especially if the angles of the prism at the base *BC* be each about 40 degrees. For the rays *FM* begin to be totally reflected when the angle *CMF* is about 50 degrees, and therefore they will then make a right angle of 90 degrees with *AC*.

Light dif-
ferently
refrangible.

"It appears also from experiments, that the beam of light *MN*, reflected by the base of the prism, being augmented first by the more refrangible rays and afterwards by the less refrangible, is composed of rays differently refrangible.

"The light whose rays are all alike refrangible, I call *simple*, *homogeneous*, and *similar*; and that whose rays are some more refrangible than others, I call *compound*, *heterogeneous*, and *dissimilar*. The former light I call *homogeneous*, not because I would affirm it so in all respects; but because the rays which agree in refrangibility agree at least in all their other properties which I consider in the following discourse.

"The colours of homogeneous lights I call *primary*, *homogeneous*, and *simple*; and those of heterogeneous lights, *heterogeneous* and *compound*. For these are always compounded of homogeneous lights, as will appear in the following discourse.

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Colours
simple or
compound

"The homogeneous light and rays which appear red, or rather make objects appear so, I call *rubrific* or *red-making*; those which make objects appear yellow, green, blue, and violet, I call *yellow-making*, *green-making*, *blue-making*, *violet-making*; and so of the rest. And if at any time I speak of light and rays as coloured or endowed with colours, I would be understood to speak not philosophically and properly, but grossly, and according to such conceptions as vulgar people

Light differently refrangible.

Light differently refrangible.

people in seeing all these experiments would be apt to frame. For the rays, to speak properly, are not coloured. In them there is nothing else than a certain power and disposition to stir up a sensation of this or that colour. For as sound, in a bell or musical string or other sounding body, is nothing but a trembling motion, and in the air nothing but that motion propagated from the object, and in the sensorium it is a sense of that motion under the form of sound; so colours in the object are nothing but a disposition to reflect this or that sort of rays more copiously than the rest: in rays they are nothing but their dispositions to propagate this or that motion into the sensorium; and in the sensorium they are sensations of those motions under the forms of colours. See CHROMATICS.

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Why the image of the sun, by heterogeneous rays passing through a prism, is oblong. Plate CCCLX.

“By the mathematical proposition above-mentioned, it is certain that the rays which are equally refrangible do fall upon a circle answering to the sun's apparent disk, which will also be proved by experiment by and by. Now let AG (fig. 5.) represent the circle which all the most refrangible rays, propagated from the whole disk of the sun, would illuminate and paint upon the opposite wall if they were alone; EL the circle, which all the least refrangible rays would in like manner illuminate if they were alone; BH, CI, DK, the circles which so many intermediate sorts would paint upon the wall, if they were singly propagated from the sun in successive order, the rest being intercepted; and conceive that there are other circles without number, which innumerable other intermediate sorts of rays would successively paint upon the wall, if the sun should successively emit every sort apart. And seeing the sun emits all these sorts at once, they must all together illuminate and paint innumerable equal circles; of all which, being according to their degrees of refrangibility placed in order in a continual series, that oblong spectrum PT is composed, which was described in the first experiment.

“Now if these circles, whilst their centres, keep their distances and positions, could be made less in diameter, their interfering one with another, and consequently the mixture of the heterogeneous rays, would be proportionably diminished. Let the circles AG, BH, CI, &c. remain as before; and let *ag*, *bb*, *ci*, &c. be so many less circles lying in a like continual series, between two parallel right lines *ae* and *gl*, with the same distances between their centres, and illuminated with the same sorts of rays: that is, the circle *ag* with the same sort by which the corresponding circle AG was illuminated; and the rest of the circles *bb*, *ci*, *dk*, *el* respectively with the same sorts of rays by which the corresponding circles BH, CI, DK, EL, were illuminated. In the figure PT, composed of the great circles, three of those, AG, BH, CI, are so expanded into each other, that three sorts of rays, by which those circles are illuminated, together with innumerable other sorts of intermediate rays, are mixed at QR in the middle of the circle BH. And the like mixture happens throughout almost the whole length of the figure PT. But in the figure *pt*, composed of the less circles, the three less circles *ag*, *bb*, *ci*, which answer to those three greater, do not extend into one another; nor are there anywhere mingled so much as any two of the three sorts of rays by which those circles are illuminated, and which in the figure PT are all of them in-

termingled at QR. So then, if we would diminish the mixture of the rays, we are to diminish the diameters of the circles. Now these would be diminished if the sun's diameter, to which they answer, could be made less than it is, or (which comes to the same purpose) if without doors, at a great distance from the prism towards the sun, some opaque body were placed with a round hole in the middle of it to intercept all the sun's light, except so much as coming from the middle of his body could pass through that hole to the prism. For so the circles AG, BH, and the rest, would not any longer answer to the whole disk of the sun, but only to that part of it which could be seen from the prism through that hole; that is, to the apparent magnitude of that hole viewed from the prism. But that these circles may answer more distinctly to that hole, a lens is to be placed by the prism to cast the image of the hole (that is, every one of the circles AG, BH, &c.) distinctly upon the paper at PT; after such a manner, as by a lens placed at a window the pictures of objects abroad are cast distinctly upon a paper within the room. If this be done, it will not be necessary to place that hole very far off, no not beyond the window. And therefore, instead of that hole, I used the hole in the window-shut as follows.

“In the sun's light let into my darkened chamber through a small round hole in my window-shut, at about 10 or 12 feet from the window, I placed a lens MN (fig. 6.), by which the image of the hole F might be distinctly cast upon a sheet of white paper placed at I. Then immediately after the lens I placed a prism ABC, by which the trajected light might be refracted either upwards or sideways, and thereby the round image which the lens alone did cast upon the paper at I, might be drawn out into a long one with parallel sides, as represented at *pt*. This oblong image I let fall upon another paper at about the same distance from the prism as the image at I, moving the paper either towards the prism or from it, until I found the just distance where the rectilinear sides of the image *pt* become most distinct. For in this case the circular images of the hole, which compose that image, after the manner that the circles *ag*, *bb*, *ci*, &c. do the figure *pt*, were terminated most distinctly, and therefore extended into one another the least that they could, and by consequence the mixture of the heterogeneous rays was now the least of all. The circles *ag*, *bb*, *ci*, &c. which compose the image *pt*, are each equal to the circle at I; and therefore, by diminishing the hole F, or by removing the lens farther from it, may be diminished at pleasure, whilst their centres keep the same distances from each other. Thus, by diminishing the breadth of the image *pt*, the circles of heterogeneous rays that compose it may be separated from each other as much as you please. Yet instead of the circular hole F, it is better to substitute an oblong hole shaped like a parallelogram, with its length parallel to the length of the prism. For if this hole be an inch or two long, and but a 10th or 20th part of an inch broad, or narrower, the light of the image *pt* will be as simple as before, or simpler; and the image being much broader, is therefore fitter to have experiments tried in its light than before.

“Homogeneous light is refracted regularly without any dilatation, splitting, or shattering of the rays; and

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the confused vision of objects seen through refracting bodies by heterogeneous light, arises from the different refrangibility of several sorts of rays. This will appear by the experiments which will follow. In the middle of a black paper I made a round hole about a fifth or a sixth part of an inch in diameter. Upon this paper I caused the spectrum of homogeneous light, described in the former article, so to fall that some part of the light might pass through the hole in the paper. This transmitted part of the light I refracted with a prism placed behind the paper: and letting this refracted light fall perpendicularly upon a white paper, two or three feet distant from the prism, I found that the spectrum formed on the paper by this light was not oblong, as when it is made in the first experiment, by refracting the sun's compound light, but was, so far as I could judge by my eye, perfectly circular, the length being nowhere greater than the breadth; which shows that this light is refracted regularly without any dilatation of the rays, and is an ocular demonstration of the mathematical proposition mentioned above.

"In the homogeneous light I placed a paper circle of a quarter of an inch in diameter: and in the sun's unrefracted, heterogeneous, white light, I placed another paper circle of the same bigness; and going from these papers to the distance of some feet, I viewed both circles through a prism. The circle illuminated by the sun's heterogeneous light appeared very oblong, as in the second experiment, the length being many times greater than the breadth. But the other circle illuminated with homogeneous light appeared circular, and distinctly defined, as when it is viewed by the naked eye; which proves the whole proposition mentioned in the beginning of this article.

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Vision
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"In the homogeneous light I placed flies and such like minute objects, and viewing them through a prism I saw their parts as distinctly defined as if I had viewed them with the naked eye. The same objects placed in the sun's unrefracted heterogeneous light, which was white, I viewed also through a prism, and saw them most confusedly defined, so that I could not distinguish their smaller parts from one another. I placed also the letters of a small print one while in the homogeneous light, and then in the heterogeneous; and viewing them through a prism, they appeared in the latter case so confused and indistinct that I could not read them; but in the former, they appeared so distinct that I could read readily, and thought I saw them as distinct as when I viewed them with my naked eye: in both cases, I viewed the same objects through the same prism, at the same distance from me, and in the same situation. There was no difference but in the lights by which the objects were illuminated, and which in one case was simple, in the other compound; and therefore the distinct vision in the former case, and confused in the latter, could arise from nothing else than from that difference in the lights. Which proves the whole proposition.

"In these three experiments, it is farther very re-

markable, that the colour of homogeneous light was never changed by the refraction. And as these colours were not changed by refractions, so neither were they by reflections. For all white, grey, red, yellow, green, blue, violet bodies, as paper, ashes, red lead, orpiment, indigo, bice, gold, silver, copper, grass, blue flowers, violets, bubbles of water tinged with various colours, peacocks feathers, the tincture of lignum nephriticum, and such like, in red homogeneous light appeared totally red, in blue light totally blue, in green light totally green, and so of other colours. In the homogeneous light of any colour they all appeared totally of that same colour; with this only difference, that some of them reflected that light more strongly, others more faintly. I never yet found any body which by reflecting homogeneous light could sensibly change its colour.

"From all which it is manifest, that if the sun's light consisted of but one sort of rays, there would be but one colour in the world, nor would it be possible to produce any new colour by reflections and refractions; and by consequence, that the variety of colours depends upon the composition of light.

"The solar image *pt*, formed by the separated rays in the 5th experiment, did in the progress from its end *p*, on which the most refrangible rays fell, unto its end *t*, on which the least refrangible rays fell, appear tinged with this series of colours; violet, indigo, blue, green, yellow, orange, red, together with all their intermediate degrees in a continual succession perpetually varying; so that there appeared as many degrees of colours as there were sorts of rays differing in refrangibility. And since these colours could not be changed by refractions nor by reflections, it follows, that all homogeneous light has its proper colour answering to its degree of refrangibility.

"Every homogeneous ray considered apart is refracted, according to one and the same rule; so that its fine of incidence is to its fine of refraction in a given ratio: that is, every different coloured ray has a different ratio belonging to it. This our author has proved by experiment, and by other experiments has determined by what numbers those given ratios are expressed. For instance, if an heterogeneous white ray of the sun emerges out of glass into air; or, which is the same thing, if rays of all colours be supposed to succeed one another in the same line AC, and AD (fig. 15.) their common fine of incidence in glass be divided into 50 equal parts, then EF and GH, the fines of refraction into air, of the least and most refrangible rays, will be 77 and 78 such parts respectively. And since every colour has several degrees, the fines of refraction of all the degrees of red will have all intermediate degrees of magnitude from 77 to $77\frac{1}{8}$, of all the degrees of orange from $77\frac{1}{8}$ to $77\frac{1}{2}$, of yellow from $77\frac{1}{2}$ to $77\frac{3}{4}$, of green from $77\frac{3}{4}$ to $77\frac{7}{8}$, of blue from $77\frac{7}{8}$ to $77\frac{15}{16}$, of indigo from $77\frac{15}{16}$ to $77\frac{31}{32}$, and of violet from $77\frac{31}{32}$ to 78."

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SECT. I. *The Application of the foregoing Theory to several natural Phenomena.*§ 1. *Of the Rainbow.*201
Knowledge
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rainbow a
modern dis-
covery.

THIS beautiful phenomenon hath engaged the attention of all ages. By some nations it hath been deified; though the more sensible part always looked upon it as a natural appearance, and endeavoured, however imperfectly, to account for it. The observations of the ancients and philosophers of the middle ages concerning the rainbow were such as could not have escaped the notice of the most illiterate husbandmen who gazed at the sky; and their various hypotheses deserve no notice. It was a considerable time even after the dawn of true philosophy in this western part of the world, before we find any discovery of importance on this subject. Maurolycus was the first who pretended to have measured the diameters of the two rainbows with much exactness; and he reports, that he found that of the inner bow to be 45 degrees, and that of the outer bow 56; from which Descartes takes occasion to observe, how little we can depend upon the observations of those who were not acquainted with the cause of the appearances.

One *Glichtovæus* (the same, it is probable, who distinguished himself by his opposition to Luther, and who died in 1543) had maintained, that the second bow is the image of the first, as he thought was evident from the inverted order of the colours. For, said he, when we look into the water, all the images that we see reflected by it are inverted with respect to the objects themselves; the tops of the trees, for instance, that stand near the brink, appearing lower than the roots.

That the rainbow is opposite to the sun, had always been observed. It was, therefore, natural to imagine, that the colours of it were produced by some kind of reflection of the rays of light from drops of rain, or vapour. The regular order of the colours was another circumstance that could not have escaped the notice of any person. But, notwithstanding mere reflection had in no other case been observed to produce colours, and it could not but have been observed that refraction is frequently attended with that phenomenon, yet no person seems to have thought of having recourse to a proper refraction in this case, before one *Fletcher* of Breslau, who, in a treatise which he published in 1571, endeavoured to account for the colours of the rainbow by means of a double refraction and one reflection. But he imagined that a ray of light, after entering a drop of rain, and suffering a refraction both at its entrance and exit, was afterwards reflected from another drop, before it reached the eye of the spectator. He seems to have overlooked the reflection at the farther side of the drop, or to have imagined that all the bendings of the light within the drop would not make a sufficient curvature to bring the ray of the sun to the eye of the spectator. That he should think of two refractions, was the ne-

N^o 248.

cessary consequence of his supposing that the ray entered the drop at all. This supposition, therefore, was all the light that he threw upon the subject. B. Porta supposed that the rainbow is produced by the refraction of light in the whole body of rain or vapour, but not in the separate drops.

After all, it was a man whom no writers allow to have had any pretensions to philosophy, that hit upon this curious discovery. This was Antonio De Dominis, bishop of Spalatro, whose treatise *De Radiis Visus et Lucis*, was published by J. Bartolus in 1611. He first advanced, that the double refraction of Fletcher, with an intervening reflection, was sufficient to produce the colours of the bow, and also to bring the rays that formed them to the eye of the spectator, without any subsequent reflection. He distinctly describes the progress of a ray of light entering the upper part of the drop, where it suffers one refraction, and after being thereby thrown upon the back part of the inner surface, is from thence reflected to the lower part of the drop; at which place undergoing a second refraction, it is thereby bent, so as to come directly to the eye. To verify this hypothesis, this person (no philosopher as he was) proceeded in a very sensible and philosophical manner. For he procured a small globe of solid glass, and viewing it when it was exposed to the rays of the sun, in the same manner in which he had supposed that the drops of rain were situated with respect to them, he actually observed the same colours which he had seen in the true rainbow, and in the same order.

Thus the circumstances in which the colours of the rainbow were formed, and the progress of a ray of light through a drop of water, were clearly understood; but philosophers were a long time at a loss when they endeavoured to assign reasons for all the particular colours, and for the order of them. Indeed nothing but the doctrine of the different refrangibility of the rays of light, which was a discovery reserved for the great Sir Isaac Newton, could furnish a complete solution of this difficulty. De Dominis supposed that the red rays were those which had traversed the least space in the inside of a drop of water, and therefore retained more of their native force, and consequently, striking the eye more briskly, gave it a stronger sensation; that the green and blue colours were produced by those rays, the force of which had been, in some measure, obtunded in passing through a greater body of water; and that all the intermediate colours were composed (according to the hypothesis which generally prevailed at that time) of a mixture of these three primary ones. That the different colours were caused by some difference in the impulse of light upon the eye, and the greater or less impression that was thereby made upon it, was an opinion which had been adopted by many persons, who had ventured to depart from the authority of Aristotle.

Afterwards the same De Dominis observed, that all the rays of the same colour must leave the drop of water in a part similarly situated with respect to the eye,

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in order that each of the colours may appear in a circle, the centre of which is a point of the heavens, in a line drawn from the sun through the eye of the spectator. The red rays, he observed, must issue from the drop nearest to the bottom of it, in order that the circle of red may be the outermost, and therefore the most elevated in the bow.

Notwithstanding De Dominis conceived so justly of the manner in which the inner rainbow is formed, he was far from having as just an idea of the cause of the exterior bow. This he endeavoured to explain in the very same manner in which he had done the interior, viz. by one reflection of the light within the drop, preceded and followed by a refraction; supposing only that the rays which formed the exterior bow were returned to the eye by a part of the drop lower than that which transmitted the red of the interior bow. He also supposed that the rays which formed one of the bows came from the superior part of the sun's disk, and those which formed the other from the inferior part of it. He did not consider, that upon those principles, the two bows ought to have been contiguous; or rather, that an indefinite number of bows would have had their colours all intermixed; which would have been no bow at all.

When Sir Isaac Newton discovered the different refrangibility of the rays of light, he immediately applied his new theory of light and colours to the phenomena of the rainbow, taking this remarkable object of philosophical inquiry where De Dominis and Descartes, for want of this knowledge, were obliged to leave their investigations imperfect. For they could give no good reason why the bow should be coloured, and much less could they give any satisfactory account of the order in which the colours appear.

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The true
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colours of
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If different particles of light had not different degrees of refrangibility, on which the colours depend, the rainbow, besides being much narrower than it is, would be colourless; but the different refrangibility of differently coloured rays being admitted, the reason is obvious, both why the bow should be coloured, and also why the colours should appear in the order in which they are observed. Let *a* (fig. 8.) be a drop of water, and *S* a pencil of light; which, on its leaving the drop of water, reaches the eye of the spectator. This ray, at its entrance into the drop, begins to be decomposed into its proper colours; and upon leaving the drop, after one reflection and a second refraction, it is farther decomposed into as many small differently coloured pencils as there are primitive colours in the light. Three of them only are drawn in this figure, of which the blue is the most, and the red the least refracted.

Plate
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The doctrine of the different refrangibility of light enables us to give a reason for the size of a bow of each particular colour. Newton, having found that the sines of refraction of the most refrangible and least refrangible rays, in passing from rain-water into air, are in the proportion of 185 to 182, when the sine of incidence is 138, calculated the size of the bow; and he found, that if the sun was only a physical point, without sensible magnitude, the breadth of the inner bow would be 2 degrees; and if to this 30' was added for the apparent diameter of the sun, the whole breadth would be $2\frac{1}{2}$ degrees. But as the outermost

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colours, especially the violet, are extremely faint, the breadth of the bow will not in reality appear to exceed two degrees. He finds, by the same principles, that the breadth of the exterior bow, if it was everywhere equally vivid, would be $4^{\circ} 20'$. But in this case there is a greater deduction to be made, on account of the faintness of the light of the exterior bow; so that, in fact, it will not appear to be more than 3 degrees broad.

The principal phenomena of the rainbow are all explained on Sir Isaac Newton's principles in the following propositions.

When the rays of the sun fall upon a drop of rain and enter into it, some of them, after one reflection and two refractions, may come to the eye of a spectator who has his back towards the sun, and his face towards the drop.

IF XY (fig. 9.) is a drop of rain, and the sun shines upon it in any lines *sf*, *sd*, *sa*, &c. most of the rays will enter into the drop; some few of them only will be reflected from the first surface; those rays which are reflected from thence do not come under our present consideration, because they are never refracted at all. The greatest part of the rays then enter the drop, and those passing on to the second surface, will most of them be transmitted through the drop; but neither do those rays which are thus transmitted fall under our present consideration, since they are not reflected. For the rays, which are described in the proposition, are such as are twice refracted and once reflected. However, at the second surface, or hinder part of the drop, at *pg*, some few rays will be reflected, whilst the rest are transmitted: those rays proceed in some such lines as *nr*, *nq*; and coming out of the drop in the lines *rv*, *qt*, may fall upon the eye of a spectator, who is placed anywhere in those lines, with his face towards the drop, and consequently with his back towards the sun, which is supposed to shine upon the drop in the lines *sf*, *sd*, *sa*, &c. These rays are twice refracted and once reflected; they are refracted when they pass out of the air into the drop; they are reflected from the second surface, and are refracted again when they pass out of the drop into the air.

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Explana-
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When rays of light reflected from a drop of rain come to the eye, those are called effectual which are able to excite a sensation.

When rays of light come out of a drop of rain, they will not be effectual, unless they are parallel and contiguous.

THERE are but few rays that can come to the eye at all: for since the greatest part of those rays which enter the drop XY (fig. 9.) between *X* and *a*, pass out of the drop through the hinder surface *pg*; only few are reflected from thence, and come out through the nearer surface between *a* and *y*. Now, such rays as emerge, or come out of the drop, between *a* and *Y*, will be ineffectual, unless they are parallel to one another, as *rv* and *qt* are; because such rays as come out diverging from one another will be so far asunder when they come to the eye, that all of them cannot enter the pupil; and the very few that can enter it will not be

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sufficient to excite any sensation. But even rays, which are parallel, as rv , qt , will not be effectual, unless there are several of them contiguous or very near to one another. The two rays rv and qt alone will not be perceived, though both of them enter the eye; for so very few rays are not sufficient to excite a sensation.

When rays of light come out of a drop of rain after one reflection, those will be effectual which are reflected from the same point, and which entered the drop near to one another.

Plate
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ANY rays, as sb and cd , (fig. 10.) when they have passed out of the air into a drop of water, will be refracted towards the perpendiculars bl , dl ; and as the ray sb falls farther from the axis av than the ray cd , sb will be more refracted than cd ; so that these rays, though parallel to one another at their incidence, may describe the lines be and de after refraction, and be both of them reflected from one and the same point e . Now all rays which are thus reflected from one and the same point, when they have described the lines ef , eg , and after reflection emerge at f and g , will be so refracted, when they pass out of the drop into the air, as to describe the lines fb , gi , parallel to one another. If these rays were to return from e in the lines eb , ed , and were to emerge at b and d , they would be refracted into the lines of their incidence bs , dc . But if these rays, instead of being returned in the lines eb , ed , are reflected from the same point e in the lines eg , ef , the lines of reflection eg and ef will be inclined both to one another, and to the surface of the drop; just as much as the lines eb and ed are. First eb and eg make just the same angle with the surface of the drop: for the angle ben , which eb makes with the surface of the drop, is the complement of incidence, and the angle gev , which eg makes with the surface, is the complement of reflection; and these two are equal to one another. In the same manner we might prove, that ed and ef make equal angles with the surface of the drop. Secondly, The angle bed is equal to the angle feg ; or the reflected rays eg , ef , and the incident rays be , de , are equally inclined to each other. For the angle of incidence bel is equal to the angle of reflection gel , and the angle of incidence del is equal to the angle of reflection fel ; consequently the difference between the angles of incidence is equal to the difference between the angles of reflection, or $bel - del = gel - fel$, or $bed = gef$. Since therefore either the lines eg , ef , or the lines eb , ed , are equally inclined both to one another and to the surface of the drop; the rays will be refracted in the same manner, whether they were to return in the lines eb , ed , or are reflected in the lines eg , ef . But if they were to return in the lines eb , ed , the refraction, when they emerge at b and d , would make them parallel. Therefore, if they are reflected from one and the same point e in the lines eg , ef , the refraction, when they emerge at g and f , will likewise make them parallel.

But though such rays as are reflected from the same point in the hinder part of a drop of rain, are parallel to one another when they emerge, and so have one condition that is requisite towards making them effectual, yet there is another condition necessary; for rays,

that are effectual, must be contiguous as well as parallel. And though rays, which enter the drop in different places, may be parallel when they emerge, those only will be contiguous which enter it nearly at the same place.

Let XY (fig. 9) be a drop of rain, ag the axis or diameter of the drop, and sa a ray of light that comes from the sun and enters the drop at the point a . This ray sa , because it is perpendicular to both the surfaces, will pass straight through the drop in the line agb without being refracted; but any collateral rays, such as those that fall about sb , as they pass through the drop, will be made to converge to their axis, and passing out at n will meet the axis at b : rays which fall farther from the axis than sb , such as those which fall about sc , will likewise be made to converge; but then their focus will be nearer to the drop than b . Suppose therefore i to be the focus to which the rays that fall about sc will converge, any ray sc , when it has described the line co within the drop, and is tending to the focus i , will pass out of the drop at the point o . The rays that fall upon the drop about sd , more remote still from the axis, will converge to a focus still nearer than i , as suppose at k . These rays therefore go out of the drop at p . The rays, that fall still more remote from the axis, as se , will converge to a focus nearer than k , as suppose at l ; and the ray se , when it has described the line eo within the drop, and is tending to l , will pass out at the point o . The rays that fall still more remote from the axis will converge to a focus still nearer. Thus the ray sf will after refraction converge to a focus at m , which is nearer than l ; and having described the line fn within the drop, it will pass out to the point n . Now here we may observe, that as any rays sb or sc , fall farther above the axis sa , the points n , or o , where they pass out behind the drop, will be farther above g ; or that, as the incident ray rises from the axis sa , the arc gn increases, till we come to some ray sd , which passes out of the drop at p ; and this is the highest point where any ray that falls upon the quadrant or quarter ax can pass out: for any rays se , or sf , that fall higher than sd , will not pass out in any point above p , but at the points o or n , which are below it. Consequently, though the arc $gnop$ increases, whilst the distance of the incident ray from the axis sa increases, till we come to the ray sd ; yet afterwards, the higher the ray falls above the axis sa , this arc $pong$ will decrease.

We have hitherto spoken of the points on the hinder part of the drop, where the rays pass out of it; but this was for the sake of determining the points from whence those rays are reflected, which do not pass out behind the drop. For, in explaining the rainbow, we have no farther reason to consider those rays which go through the drop; since they can never come to the eye of a spectator placed anywhere in the lines rv or qt with his face towards the drop. Now, as there are many rays which pass out of the drop between g and p , so some few rays will be reflected from thence; and consequently the several points between g and p , which are the points where some of the rays pass out of the drop, are likewise the points of reflection for the rest which do not pass out. Therefore, in respect of those rays which are reflected, we may call gp the arc of reflection; and may say, that this arc

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of reflection increases, as the distance of the incident ray from the axis sa increases, till we come to the ray sd ; the arc of reflection is gn for the ray sb , it is go for the ray sc ; and gp for the ray sd . But after this, as the distance of the incident ray from the axis sa increases, the arc of reflection decreases; for og less than pg is the arc of reflection for the ray se , and ng is the arc of reflection for the ray sf .

From hence it is obvious, that some one ray, which falls above sd , may be reflected from the same point with some other ray which falls below sd . Thus, for instance, the ray sb will be reflected from the point n , and the ray sf will be reflected from the same point; and consequently, when the reflected rays nr , ng , are refracted as they pass out of the drop at r and q , they will be parallel, by what has been shown in the former part of this proposition. But since the intermediate rays, which enter the drop between sf and sb , are not reflected from the same point n , these two rays alone will be the parallel to one another when they come out of the drop, and the intermediate rays will not be parallel to them. And consequently these rays rv , qt , though they are parallel after they emerge at r and q , will not be contiguous, and for that reason will not be effectual; the ray sd is reflected from p , which has been shown to be the limit of the arc of reflection; such rays as fall just above sd , and just below sd , will be reflected from nearly the same point p , as appears from what has been already shown. These rays therefore will be parallel, because they are reflected from the same point p ; and they will likewise be contiguous, because they all of them enter the drop at one and the same place very near to d . Consequently, such rays as enter the drop at d , and are reflected from p the limit of the arc of reflection, will be effectual; since, when they emerge at the fore part of the drop between a and y , they will be both parallel and contiguous.

If we can make out hereafter that the rainbow is produced by the rays of the sun which are thus reflected from drops of rain as they fall whilst the sun shines upon them, this proposition may serve to show us, that this appearance is not produced by any rays that fall upon any part, and are reflected from any part of those drops: since this appearance cannot be produced by any rays but those which are effectual; and effectual rays must always enter each drop at one certain place in the fore-part of it, and must likewise be reflected from one certain place in the hinder surface.

When rays that are effectual emerge from a drop of rain after one reflection and two refractions, those which are most refrangible will, at their emerſion, make a leſs angle with the incident rays than thoſe do which are leaſt refrangible; and by this means the rays of different colours will be ſeparated from one another.

Plate
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LET fb and gi (fig. 10.) be effectual violet rays emerging from the drop at fg ; and fn , gp , effectual red rays emerging from the same drop at the same place. Now, though all the violet rays are parallel to one another, because they are supposed effectual, and though all the red rays are likewise parallel to one another for the same reason; yet the violet rays will not be parallel to the red rays. These rays, as they have different colours, and different degrees of re-

frangibility, will diverge from one another; any violet ray gi , which emerges at g , will diverge from any red ray gp , which emerges at the same place. Now, both the violet ray gi , and the red ray gp , as they pass out of the drop of water into the air, will be refracted from the perpendicular lo . But the violet ray is more refrangible than the red one; and for that reason gi , or the refracted violet ray, will make a greater angle with the perpendicular than gp the refracted red ray; or the angle igo will be greater than the angle pgo . Suppose the incident ray sb to be continued in the direction sk , and the violet ray ig to be continued backward in the direction ik , till it meets the incident ray at k . Suppose likewise the red ray pg to be continued backwards in the same manner, till it meets the incident ray at w . The angle ik is that which the violet ray, or most refrangible ray at its emerſion, makes with the incident ray; and the angle pws is that which the red ray, or least refrangible ray at its emerſion, makes with the incident ray. The angle iks is less than the angle pws . For, in the triangle, gwk , gws , or pws , is the external angle at the base, and gkw or iks is one of the internal opposite angles; and either internal opposite angle is less than the external angle at the base. (Euc. b. I. prop. 16.) What has been shown to be true of the rays gi and gp might be shown in the same manner of the rays fb and fn , or of any other rays that emerge respectively parallel to gi and gp . But all the effectual violet rays are parallel to gi , and all the effectual red rays are parallel to gp . Therefore the effectual violet rays at their emerſion make a less angle with the incident ones than the effectual red ones. And for the same reason, in all the other sorts of rays, those which are most refrangible, at their emerſion from a drop of rain after one reflection, will make a less angle with the incident rays, than those do which are less refrangible.

Or otherwise: When the rays gi and gp emerge at the same point g , as they both come out of water into air, and consequently are refracted from the perpendicular, instead of going straight forwards in the line eg continued, they will both be turned round upon the point g from the perpendicular go . Now it is easy to conceive, that either of these lines might be turned in this manner upon the point g as upon a centre, till they became parallel to sb the incident ray. But if either of these lines or rays were refracted so much from go as to become parallel to sb , the ray so much refracted, would, after emerſion, make no angle with sk , because it would be parallel to it. And consequently that ray which is most turned round upon the point g , or that ray which is most refrangible, will after emerſion be nearest parallel to the incident ray, or will make the least angle with it. The same may be proved of all other rays emerging parallel to gi and gp respectively, or of all effectual rays; those which are most refrangible will after emerſion make a less angle with the incident rays, than those do which are least refrangible.

But since the effectual rays of different colours make different angles with sk at their emerſion, they will be separated from one another: so that if the eye was placed in the beam $fgbi$, it would receive only rays of one colour from the drop $xagv$; and if it was placed

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in the beam $fgnp$, it would receive only rays of some other colour.

The angle swp , which the least refrangible or red rays make with the incident ones when they emerge so as to be effectual, is found by calculation to be 42 degrees 2 minutes. And the angle ski , which the most refrangible rays make with the incident ones when they emerge so as to be effectual, is found to be 40 degrees 17 minutes. The rays which have the intermediate degrees of refrangibility, make with the incident ones intermediate angles between 42 degrees 2 minutes, and 40 degrees 17 minutes.

If a line is supposed to be drawn from the centre of the sun through the eye of the spectator, the angle which any effectual ray, after two refractions and one reflection, makes with the incident ray, will be equal to the angle which it makes with that line.

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LET the eye of the spectator be at i , (fig. 10.) and let qt be the line supposed to be drawn from the centre of the sun through the eye of the spectator; the angle git , which any effectual ray makes with this line, will be equal to the angle iks , which the same ray makes with the incident ray sb or sk . If sb is a ray coming from the centre of the sun, then since qt is supposed to be drawn from the same point, these two lines, upon account of the remoteness of the point from whence they are drawn, may be looked upon as parallel to one another. But the right line ki crossing these two parallel lines will make the alternate angles equal. (Euc. b. I. prop. 29.) Therefore kit or git is equal to ski .

When the sun shines upon the drops of rain as they are falling, the rays that come from those drops to the eye of a spectator, after one reflection and two refractions, produce the primary rainbow.

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Two rain-
bows seen
at once.

If the sun shines upon the rain as it falls, there are commonly seen two bows, as AFB, CHD, (fig. 11.); or if the cloud and rain does not reach over that whole side of the sky where the bows appear, then only a part of one or of both bows is seen in that place where the rain falls. Of these two bows, the innermost AFB is the more vivid of the two, and this is called the *primary bow*. The outer part TFY of the primary bow is red, the inner part VEX is violet; the intermediate parts, reckoning from the red to the violet, are orange, yellow, green, blue, and indigo. Suppose the spectator's eye to be at O, and let LOP be an imaginary line drawn from the centre of the sun through the eye of the spectator: if a beam of light S coming from the sun falls upon any drop F; and the rays that emerge at F in the line FO, so as to be effectual, make an angle FOP of 42° 2' with the line LP; then these effectual rays make an angle of 42° 2' with the incident rays, by the preceding proposition, and consequently these rays will be red, so that the drop F will appear red. All the other rays, which emerge at F, and would be effectual if they fell upon the eye, are refracted more than the red ones, and consequently will pass above the eye. If a beam of light S falls upon the drop E; and the rays that emerge at E in the line EO, so as to be effectual, make an angle EOP of 40° 17' with the line LP; then these effectual rays make likewise an angle of

40° 17' with the incident rays, and the drop E will appear of a violet colour. All the other rays, which emerge at E, and would be effectual if they came to the eye, are refracted less than the violet ones, and therefore pass below the eye. The intermediate drops between F and E will for the same reasons be of the intermediate colours.

Thus we have shown why a set of drops from F to E, as they are falling, should appear of the primary colours, red, orange, yellow, green, blue, indigo, and violet. It is not necessary that the several drops, which produce these colours, should all of them fall at exactly the same distance from the eye. The angle FOP, for instance, is the same whether the distance of the drop from the eye is OF, or whether it is in any other part of the line OF something nearer to the eye. And whilst the angle FOP is the same, the angle made by the emerging and incident rays, and consequently the colour of the drop, will be the same. This is equally true of any other drop. So that although in the figure the drops F and E are represented as falling perpendicularly one under the other, yet this is not necessary in order to produce the bow.

But the coloured line FE, which we have already accounted for, is only the breadth of the bow. It still remains to be shown, why not only the drop F should appear red, but why all the other drops quite from A to B in the arc ATFYB should appear of the same colour. Now it is evident, that wherever a drop of rain is placed, if the angle which the effectual rays make with the line LP is equal to the angle FOP, that is, if the angle which the effectual rays make with the incident rays is 42° 2', any of those drops will be red, for the same reason that the drop F is of this colour.

If FOP was to turn round upon the line OP, so that one end of this line should always be at the eye, and the other be at P opposite to the sun; such a motion of this figure would be like that of a pair of compasses turning round upon one of the legs OP with the opening FOP. In this revolution the drop F would describe a circle, P would be the centre, and ATFYB would be an arc in this circle. Now since, in this motion of the line and drop OF, the angle made by FO with OP, that is, the angle FOP, continues the same; if the sun was to shine upon this drop as it revolves, the effectual rays would make the same angle with the incident rays, in whatever part of the arc ATFYB the drop was to be. Therefore, whether the drop is at A, or at T, or at Y, or at B, or wherever else it is in this whole arc, it would appear red, as it does at F. The drops of rain, as they fall, are not indeed turned round in this manner: but then, as innumerable of them are falling at once in right lines from the cloud, whilst one drop is at F, there will be others at Y, at T, at B, at A, and in every other part of the arc ATFYB: and all these drops will be red for the same reason that the drop F would have been red, if it had been in the same place. Therefore, when the sun shines upon the rain as it falls, there will be a red arc ATFYB opposite to the sun. In the same manner, because the drop E is violet, we might prove that any other drop, which, whilst it is falling, is in any part of the arc AVEXB, will be violet; and consequently, at the same time that the red arc ATFYB appears, there will like-
wise

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wise be a violet arc AVEXB below or within it. FE is the distance between these two coloured arcs; and from what has been said, it follows, that the intermediate space between these two arcs will be filled up with arcs of the intermediate colours, orange, yellow, blue, green, and indigo. All these coloured arcs together make up the primary rainbow.

The primary rainbow is never a greater arc than a semicircle.

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Why the
arc of the
primary
rainbow is
never
greater
than a semi-
circle.

SINCE the line LOP is drawn from the sun through the eye of the spectator, and since P (fig. 9.) is the centre of the rainbow; it follows, that the centre of the rainbow is always opposite to the sun. The angle FOP is an angle of $42^{\circ} 2'$, as was observed, or F the highest part of the bow is $42^{\circ} 2'$ from P the centre of it. If the sun is more than $42^{\circ} 2'$ high, P the centre of the rainbow, which is opposite to the sun, will be more than $42^{\circ} 2'$ below the horizon; and consequently F the top of the bow, which is only $42^{\circ} 2'$ from P, will be below the horizon; that is, when the sun is more than $42^{\circ} 2'$ high, no primary rainbow will be seen. If the sun is something less than $42^{\circ} 2'$ high, then P will be something less than $42^{\circ} 2'$ below the horizon; and consequently F, which is only $42^{\circ} 2'$ from P, will be just above the horizon; that is, a small part of the bow at this height of the sun will appear close to the ground opposite to the sun. If the sun is 20° high, then P will be 20° below the horizon; and F the top of the bow, being $42^{\circ} 2'$ from P, will be $22^{\circ} 2'$ above the horizon; therefore, at this height of the sun, the bow will be an arc of a circle whose centre is below the horizon; and consequently that arc of the circle which is above the horizon, or the bow, will be less than a semicircle. If the sun is in the horizon, then P, the centre of the bow, will be in the opposite part of the horizon; F, the top of the bow, will be $42^{\circ} 2'$ above the horizon; and the bow itself, because the horizon passes through the centre of it, will be a semicircle. More than a semicircle can never appear; because if the bow was more than a semicircle, P the centre of it must be above the horizon; but P is always opposite to the sun, therefore P cannot be above the horizon, unless the sun is below it; and when the sun is set, or is below the horizon, it cannot shine upon the drops of rain as they fall; and consequently, when the sun is below the horizon, no bow at all can be seen.

When the rays of the sun fall upon a drop of rain, some of them, after two reflections and two refractions, may come to the eye of a spectator, who has his back towards the sun and his face towards the drop.

IF HGW (fig. 12.) is a drop of rain, and parallel rays coming from the sun, as zv , yw , fall upon the lower part of it, they will be refracted towards the perpendiculars vl , wl , as they enter into it, and will describe some such lines as vb , wi . At b and i great part of these rays will pass out of the drop; but some of them will be reflected from thence in the lines bf , ig . At f and g again, great part of the rays that were reflected thither will pass out of the drop. But these rays will not come to the eye of a spectator at o . However, here again all the rays will not pass out; but some few will be reflected from f and g , in

some such lines as fd , gb ; and these, when they emerge out of the drop of water into the air at b and d , will be refracted from the perpendiculars, and, describing the lines dt , bo , may come to the eye of the spectator who has his back towards the sun and his face towards the drop.

Those rays, which are parallel to one another after they have been once refracted and once reflected in a drop of rain, will be effectual when they emerge after two refractions and two reflections.

No rays can be effectual, unless they are contiguous and parallel. From what was said, it appears, that when rays come out of a drop of rain contiguous to one another, either after one or after two reflections, they must enter the drop nearly at one and the same place. And if such rays as are contiguous are parallel after the first reflection, they will emerge parallel, and therefore will be effectual. Let zv and yw be contiguous rays which come from the sun, and are parallel to one another when they fall upon the lower part of the drop, suppose these rays to be refracted at v and w , and to be reflected at b and i ; if they are parallel to one another, as bf , gi , after this first reflection, then, after they are reflected a second time from f and g , and refracted a second time as they emerge at d and b , they will go out of the drop parallel to one another in the lines dt and bo , and will therefore be effectual.

The rays zv , yw , are refracted towards the perpendiculars vl , wl , when they enter the drop, and will be made to converge. As these rays are very oblique, their focus will not be far from the surface vw . If this focus is at k , the rays, after they have passed the focus, will diverge from thence in the directions kb , ki ; and if ki is the principal focal distance of the concave reflecting surface bi , the reflected rays bf , ig , will be parallel. These rays ef , ig , are reflected again from the concave surface fg , and will meet in a focus at e , so that ge will be the principal focal distance of this reflecting surface fg . And because bi and fg are parts of the same sphere, the principal focal distances ge and ki will be equal to one another. When the rays have passed the focus e , they will diverge from thence in the lines ed , eb ; and we are to show, that when they emerge at d and b , and are refracted there, they will become parallel.

Now if the rays vk , wk , when they have met at k , were to be turned back again in the directions kv , kw , and were to emerge at v and w , they would be refracted into the lines of their incidence, vz , wy , and therefore would be parallel. But since ge is equal to ik , as has already been shown, the rays ed , eb , that diverge from e , fall in the same manner upon the drop at d and b , as the rays kv , kw , would fall upon it at v and w ; and ed , eb , are just as much inclined to the refracting surface db , as kv , kw , would be to the surface vw . From hence it follows, that the rays ed , eb , emerging at d and b , will be refracted in the same manner, and will have the same direction in respect of one another, as kv , kw , would have. But kv and kw would be parallel after refraction. Therefore ed and eb will emerge in lines dp , bo , so as to be parallel to one another, and consequently so as to be effectual.

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When rays that are effectual emerge from a drop of rain after two reflections and two refractions, those which are most refrangible will at their emergence make a greater angle with the incident rays than those do which are least refrangible; and by this means the rays of different colours will be separated from one another.

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If rays of different colours, which are differently refrangible, emerge at any point b (fig. 12.), these rays will not be all of them equally refracted from the perpendicular. Thus, if bo is a red ray, which is of all others the least refrangible, and bm is a violet ray, which is of all others the most refrangible; when these two rays emerge at b , the violet ray will be refracted more from the perpendicular bx than the red ray, and the refracted angle xbm will be greater than the refracted angle xbo . From hence it follows, that these two rays, after emergence, will diverge from one another. In like manner, the rays that emerge at d will diverge from one another; a red ray will emerge in the line dp , a violet ray in the line dt . So that though all the effectual red rays of the beam $b d m t$ are parallel to one another, and all the effectual red rays of the beam $b d o p$ are likewise parallel to one another, yet the violet rays will not be parallel to the red ones, but the violet beam will diverge from the red beam. Thus the rays of different colours will be separated from one another.

This will appear farther, if we consider what the proposition affirms, That any violet or most refrangible ray will make a greater angle with the incident rays, than any red or least refrangible ray makes with the same incident rays. Thus if yw is an incident ray, bm a violet ray emerging from the point b , and bo a red ray emerging from the same point; the angle which the violet ray makes with the incident one is ym , and that which the red ray makes with it is yo . Now ym is a greater angle than yo . For in the triangle brs the internal angle brs is less than bsy the external angle at the base. (Eucl. B. I. prop. 16.) But ym is the complement of brs or of bry to two right angles, and yo is the complement of bsy to two right angles. Therefore, since bry is less than bsy , the complement of bry to two right angles will be greater than the complement of bsy to two right angles; or ym will be greater than yo .

Or otherwise: Both the rays bo and bm , when they are refracted in passing out of the drop at b , are turned round upon the point b from the perpendicular bx . Now either of these lines bo or bm might be turned round in this manner, till it made a right angle with yw . Consequently, that ray which is most turned round upon b , or which is most refracted, will make an angle with yw that will be nearer to a right one than that ray makes with it which is least turned round upon b , or which is least refracted. Therefore that ray which is most refracted will make a greater angle with the incident ray than that which is least refracted.

But since the emerging rays, as they are differently refrangible, make different angles with the same incident ray yw , the refraction which they suffer at emergence will separate them from one another.

The angle ym , which the most refrangible or violet rays make with the incident ones, is found by cal-

culatation to be $54^{\circ} 7'$; and the angle yo , which the least refrangible or red rays make with the incident ones, is found to be $50^{\circ} 57'$: the angles, which the rays of the intermediate colours, indigo, blue green, yellow, and orange, make with the incident rays, are intermediate angles between $54^{\circ} 7'$ and $50^{\circ} 57'$.

If a line is supposed to be drawn from the centre of the sun through the eye of the spectator; the angle which, after two refractions and two reflections, any effectual ray makes with the incident ray, will be equal to the angle which it makes with that line.

If yw (fig. 12.) is an incident ray, bo an effectual ray, and qn a line drawn from the centre of the sun through o the eye of the spectator; the angle yso , which the effectual ray makes with the incident ray, is equal to son the angle which the same effectual ray makes with the line qn . For yw and qn , considered as drawn from the centre of the sun, are parallel; bo crosses them, and consequently makes the alternate angles yso , son , equal to one another. Eucl. B. I. Prop. 29.

When the sun shines upon the drops of rain as they are falling, the rays that come from these drops to the eye of a spectator, after two reflections and two refractions, produce the secondary rainbow.

THE secondary rainbow is the outermost CHD, ²⁰⁸ The second-
fig. 11. When the sun shines upon a drop of rain H ; dary rain-
and the rays HO , which emerge at H so as to be ef- bow produ-
fectual, make an angle HOP of $54^{\circ} 7'$ with LOP a ced by two
line drawn from the sun through the eye of the spec- reflections
tator; the same effectual rays will make likewise an and two
angle of $54^{\circ} 7'$ with the incident rays S , and the rays refractions.
which emerge at this angle are violet ones, by what was observed above. Therefore, if the spectator's eye is at O , none but violet rays will enter it: for as all the other rays make a less angle with OP , they will fall above the spectator's eye. In like manner, if the effectual rays that emerge from the drop G make an angle of $50^{\circ} 57'$ with the line OP , they will likewise make the same angle with the incident rays S ; and consequently, from the drop G to the spectator's eye at O , no rays will come but red ones; for all the other rays, making a greater angle with the line OP , will fall below the eye at O . For the same reason, the rays emerging from the intermediate drops between H and G , and coming to the spectator's eye at O , will emerge at intermediate angles, and therefore will have the intermediate colours. Thus, if there are seven drops from H to G inclusively, their colours will be violet, indigo, blue, green, yellow, orange, and red. This coloured line is the breadth of the secondary rainbow.

Now, if HOP was to turn round upon the line OP , like a pair of compasses upon one of the legs OP with the opening HOP , it is plain from the supposition, that, in such a revolution of the drop H , the angle HOP would be the same, and consequently the emerging rays would make the same angle with the incident ones. But in such a revolution the drop would describe a circle of which P would be the centre, and $CNHRD$ an arc. Consequently, since, when the drop is at N , or at R , or anywhere else in that arc, the emerging rays make the same angle with the incident ones as when the drop is at H , the colour of the drop will

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will be the same to an eye placed at O, whether the drop is at N, or at H, or at R, or anywhere else in that arc. Now, though the drop does not thus turn round as it falls, and does not pass through the several parts of this arc, yet, since there are drops of rain falling everywhere at the same time, when one drop is at H, there will be another at R, another at N, and others in all parts of the arc; and these drops will all of them be violet-coloured, for the same reason that the drop H would have been of this colour if it had been in any of those places. In like manner, as the drop G is red when it is at G, it would likewise be red in any part of the arc CWGQD; and so will any other drop, when, as it is falling, it comes to any part of that arc. Thus as the sun shines upon the rain, whilst it falls, there will be two arcs produced, a violet coloured one CNHRD, and a red one CWGQD; and for the same reasons the intermediate space between these two arcs will be filled up with arcs of the intermediate colours. All these arcs together make up the secondary rainbow.

The colours of the secondary rainbow are fainter than those of the primary rainbow; and are ranged in the contrary order.

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Why the
colours of
the second-
ary rain-
bow are
fainter than
those of the
primary,
and ranged
in a con-
trary order.

THE primary rainbow is produced by such rays as have been only once reflected; the secondary rainbow is produced by such rays as have been twice reflected. But at every reflection some rays pass out of the drop of rain without being reflected; so that the oftener the rays are reflected, the fewer of them are left. Therefore the colours of the secondary bow are produced by fewer rays, and consequently will be fainter, than the colours of the primary bow.

In the primary bow, reckoning from the outside of it, the colours are ranged in this order; red, orange, yellow, green, blue, indigo, violet. In the secondary bow, reckoning from the outside, the colours are violet, indigo, blue, green, yellow, orange, red. So that the red, which is the outermost or highest colour in the primary bow, is the innermost or lowest colour in the secondary one.

Now the violet rays, when they emerge so as to be effectual after one reflection, make a less angle with the incident rays than the red ones; consequently the violet rays make a less angle with the lines OP (fig. 11.) than the red ones. But, in the primary rainbow, the rays are only once reflected, and the angle which the effectual rays make with OP is the distance of the coloured drop from P the centre of the bow. Therefore the violet drops, or violet arc, in the primary bow, will be nearer to the centre of the bow than the red drops or red arc; that is, the innermost colour in the primary bow will be violet, and the outermost colour will be red. And, for the same reason, through the whole primary bow, every colour will be nearer to the centre P, as the rays of that colour are more refrangible.

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But the violet rays, when they emerge so as to be effectual after two reflections, make a greater angle with the incident rays than the red ones; consequently the violet rays will make a greater angle with the line OP, than the red ones. But in the secondary rainbow the rays are twice reflected, and the angle which effectual rays make with OP is the distance of the co-

loured drop from P the centre of the bow. Therefore the violet drops or violet arc in the secondary bow will be farther from the centre of the bow than the red drops or red arc; that is, the outermost colour in the secondary bow will be violet, and the innermost colour will be red. And, for the same reason, through the whole secondary bow, every colour will be further from the centre P, as the rays of that colour are more refrangible.

§ 2. Of Coronas, Parhelia, &c.

UNDER the articles CORONA and PARHELION a pretty full account is given of the different hypotheses concerning these phenomena, and likewise of the method by which these hypotheses are supported, from the known laws of refraction and reflection; to which therefore, in order to avoid repetition, we must refer.

§ 3. Of the apparent Place, Distance, Magnitude, and Motion of Objects.

PHILOSOPHERS in general had taken for granted, that the place to which the eye refers any visible object seen by reflection or refraction, is that in which the visual ray meets a perpendicular from the object upon the reflecting or refracting plane. But this method of judging of the place of objects was called in question by Dr Barrow, who contended that the arguments brought in favour of the opinion were not conclusive. These arguments are, that the images of objects appear straight in a plane mirror, but curved in a convex or concave one: that a straight thread, when partly immersed perpendicularly in water, does not appear crooked as when it is obliquely plunged into the fluid; but that which is within the water seems to be a continuation of that which is without. With respect to the reflected image, however, of a perpendicular right line from a convex or concave mirror, he says, that it is not easy for the eye to distinguish the curve that it really makes; and that, if the appearance of a perpendicular thread, part of which is plunged in water, be closely attended to, it will not favour the common hypothesis. If the thread is of any shining metal, as silver, and viewed obliquely, the image of the part immersed will appear to detach itself sensibly from that part which is without the water, so that it cannot be true that every object appears to be in the same place where the refracted ray meets the perpendicular; and the same observation, he thinks, may be extended to the case of reflection. According to this writer, we refer every point of an object to the place from which the pencils of light, that give us the image of it, issue, or from which they would have issued if no reflecting or refracting substance intervened. Pursuing this principle, he proceeds to investigate the place in which the rays issuing from each of the points of an object, and which reach the eye after one reflection or refraction, meet; and he found, that if the refracting surface was plane, and the refraction was made from a denser medium into a rarer, those rays would always meet in a place between the eye and a perpendicular to the point of incidence. If a convex mirror be used, the case will be the same; but if the mirror be plane, the rays will meet in the perpendicular, and beyond it if it be concave.

The appa-
rent place,
&c. of
objects.

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Dr Bar-
row's
theory re-
specting
the appa-
rent place
of objects.

The app-
ent place,
&c. of
objects.

cave. He also determined, according to these principles, what form the image of a right line will take, when it is presented in different manners to a spherical mirror, or when it is seen through a refracting medium.

Probable as Dr Barrow thought the maxim which he endeavoured to establish, concerning the supposed place of visible objects, he has the candour to mention an objection to it, and to acknowledge that he was not able to give a satisfactory solution of it. It is this. Let an object be placed beyond the focus of a convex lens; and if the eye be close to the lens, it will appear confused, but very near to its true place. If the eye be a little withdrawn, the confusion will increase, and the object will seem to come nearer; and when the eye is very near the focus, the confusion will be exceedingly great, and the object will seem to be close to the eye. But in this experiment the eye receives no rays but those that are converging; and the point from which they issue is so far from being nearer than the object, that it is beyond it; notwithstanding which, the object is conceived to be much nearer than it is, though no very distinct idea can be formed of its precise distance. It may be observed, that in reality, the rays falling upon the eye in this case in a manner quite different from that in which they fall upon it in other circumstances, we can form no judgment about the place from which they issue. This subject was afterwards taken up by Berkeley, Smith, Montucla, and others.

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Hire's ob-
servations.

M. de la Hire made several valuable observations concerning the distance of visible objects, and various other phenomena of vision, which are well worth our notice. He also took particular pains to ascertain the manner in which the eye conforms itself to the view of objects placed at different distances. He enumerates five circumstances, which assist us in judging of the distance of objects, namely, their apparent magnitude, the strength of the colouring, the direction of the two eyes, the parallax of the objects, and the distinctness of their small parts. Painters, he says, can only take advantage of the two first mentioned circumstances, and therefore pictures can never perfectly deceive the eye; but in the decorations of theatres, they, in some measure, make use of them all. The size of objects, and the strength of their colouring, are diminished in proportion to the distance at which they are intended to appear. Parts of the same object which are to appear at different distances, as columns in an order of architecture, are drawn upon different planes, a little removed from one another, that the two eyes may be obliged to change their direction, in order to distinguish the parts of the nearer plane from those of the more remote. The small distance of the planes serves to make a small parallax, by changing the position of the eye; and as we do not preserve a distinct idea of the quantity of parallax, corresponding to the different distances of objects, it is sufficient that we perceive there is a parallax, to be convinced that these planes are distant from one another, without determining what that distance is; and as to the last circumstance, viz. the distinctness of the small parts of objects, it is of no use in discovering the deception, on account of the false light that is thrown upon these decorations.

To these observations concerning deceptions of sight, we shall add a similar one of M. le Cat, who

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took notice that the reason why we imagine objects to be larger when they are seen through a mist, is the dimness or obscurity with which they are then seen; this circumstance being associated with the idea of great distance. This he says is confirmed by our being surprised to find, upon approaching such objects, that they are so much nearer to us, as well as so much smaller, than we had imagined.

Among other cases concerning vision, which fell under the consideration of M. de la Hire, he mentions one which is of difficult solution. It is when a candle, in a dark place, and situated beyond the limits of distinct vision, is viewed through a very narrow chink in a card; in which case a considerable number of candles, sometimes so many as six, will be seen along the chink. This appearance he ascribes to small irregularities in the surface of the humours of the eye, the effect of which is not sensible when rays are admitted into the eye through the whole extent of the pupil, and consequently one principal image effaces a number of small ones; whereas, in this case, each of them is formed separately, and no one of them is so considerable as to prevent the others from being perceived at the same time.

There are few persons, M. de la Hire observes, who have both their eyes perfectly equal, not only with respect to the limits of distinct vision, but also with respect to the colour with which objects appear tinged when they are viewed by them, especially if one of the eyes has been exposed to the impression of a strong light. To compare them together in this respect, he directs us to take two thin cards, and to make in each of them a round hole of a third or a fourth of a line in diameter, and, applying one of them to each of the eyes, to look through the holes on a white paper, equally illuminated; when a circle of the paper will appear to each of the eyes, and, placing the cards properly, these two circles may be made to touch one another, and thereby the appearance of the same object to each of the eyes may be compared to the greatest advantage. To make this experiment with the greatest exactness, it is necessary, he says, that the eyes be kept shut some time before the cards be applied to them.

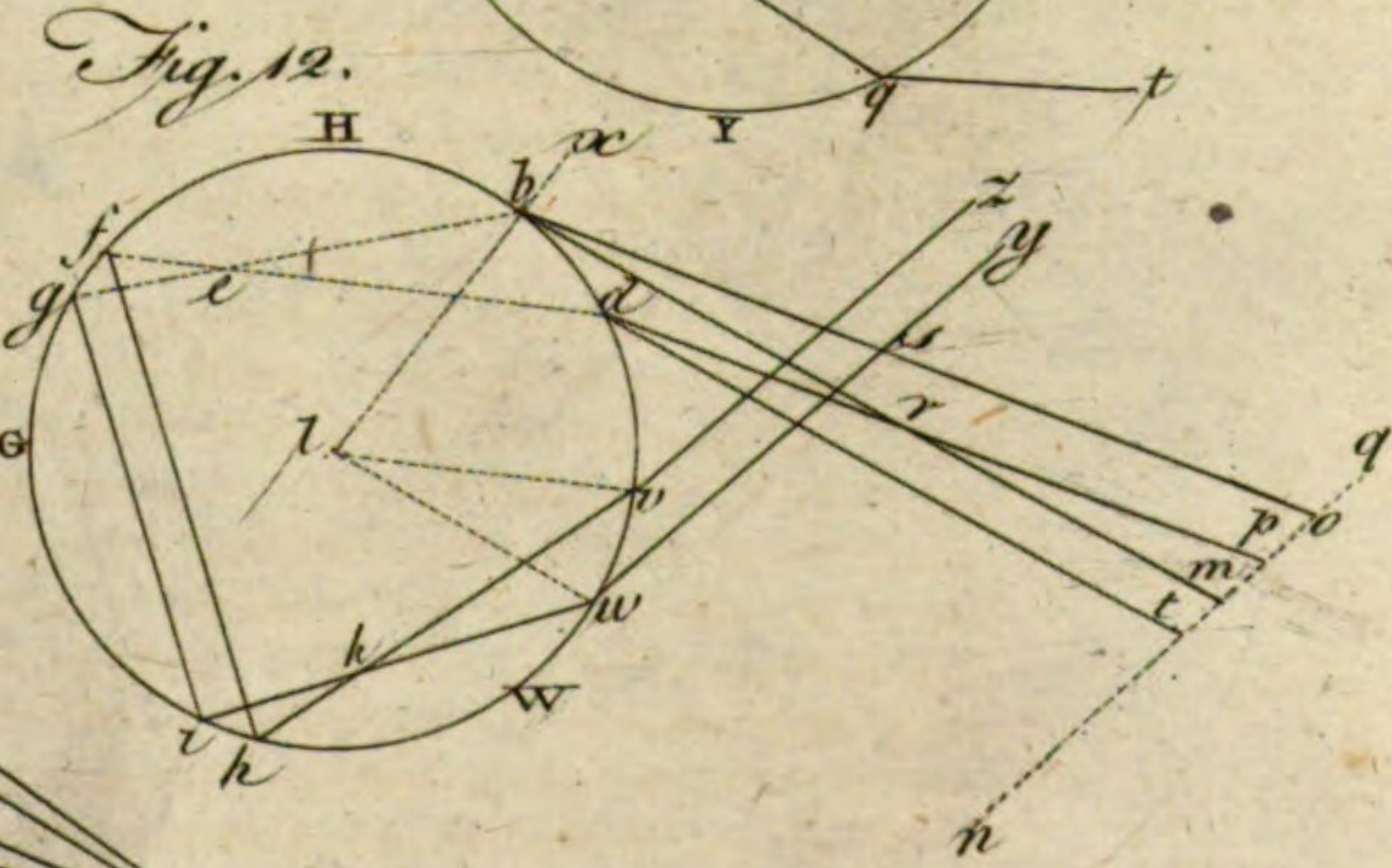
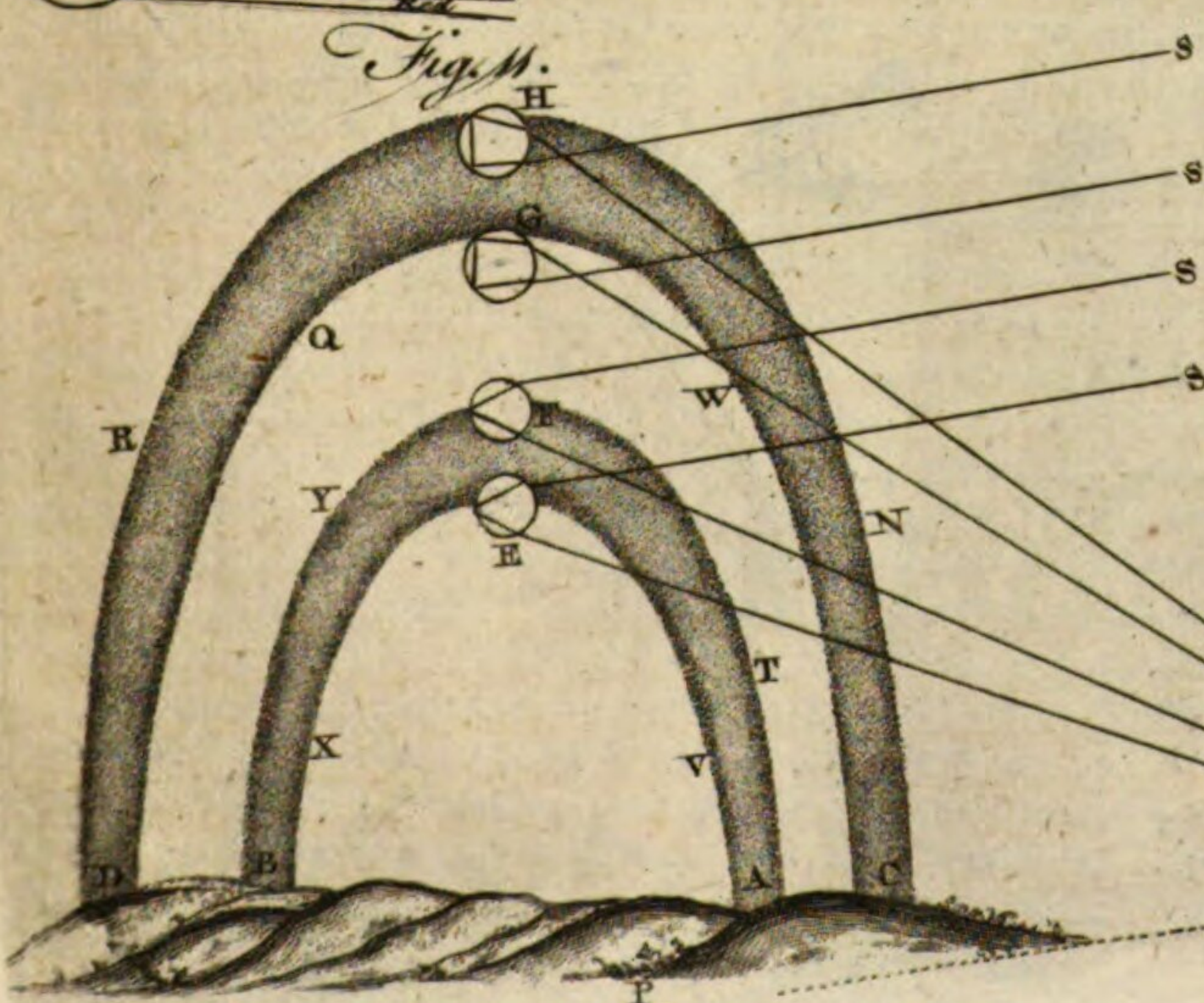
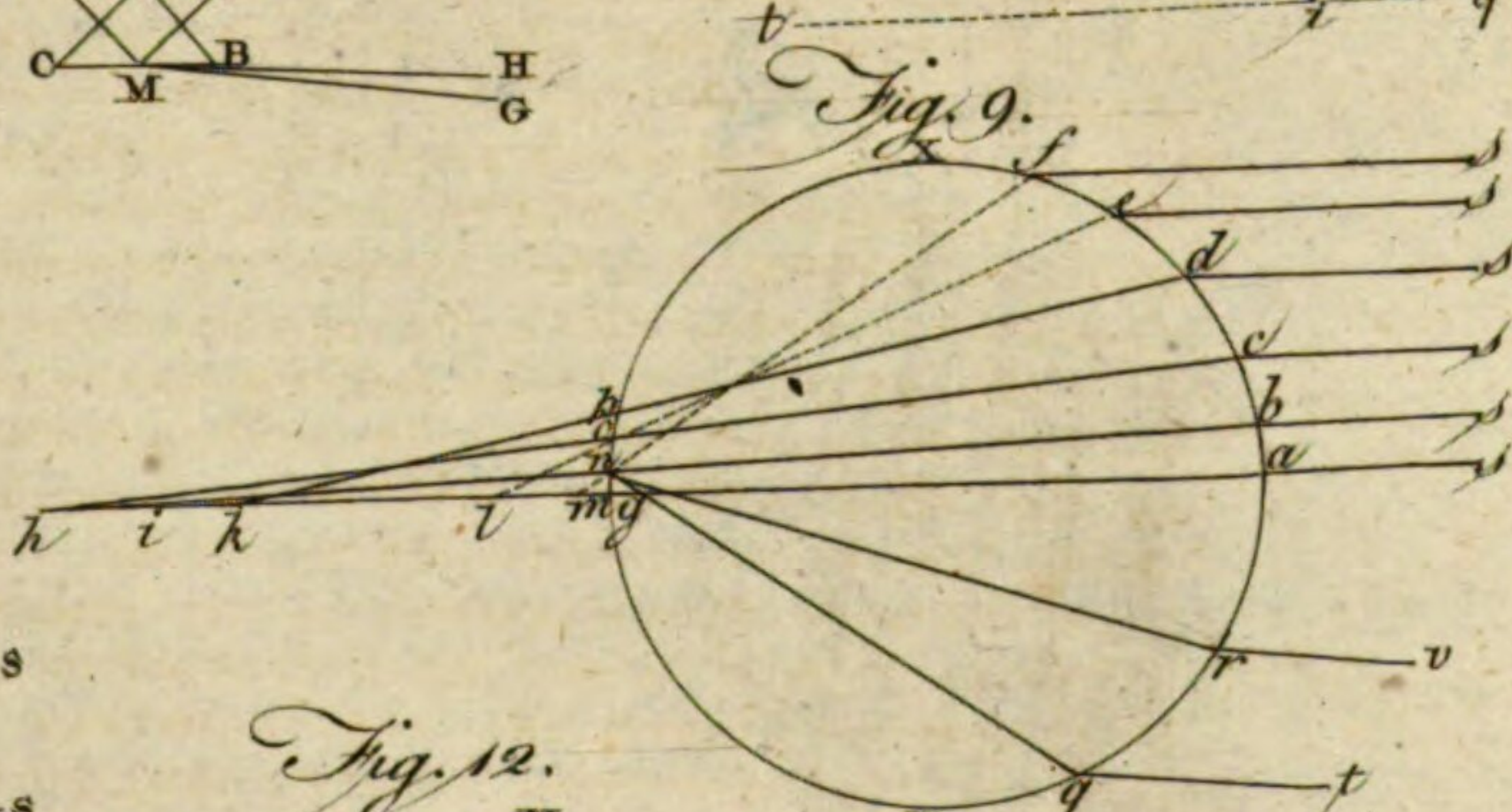
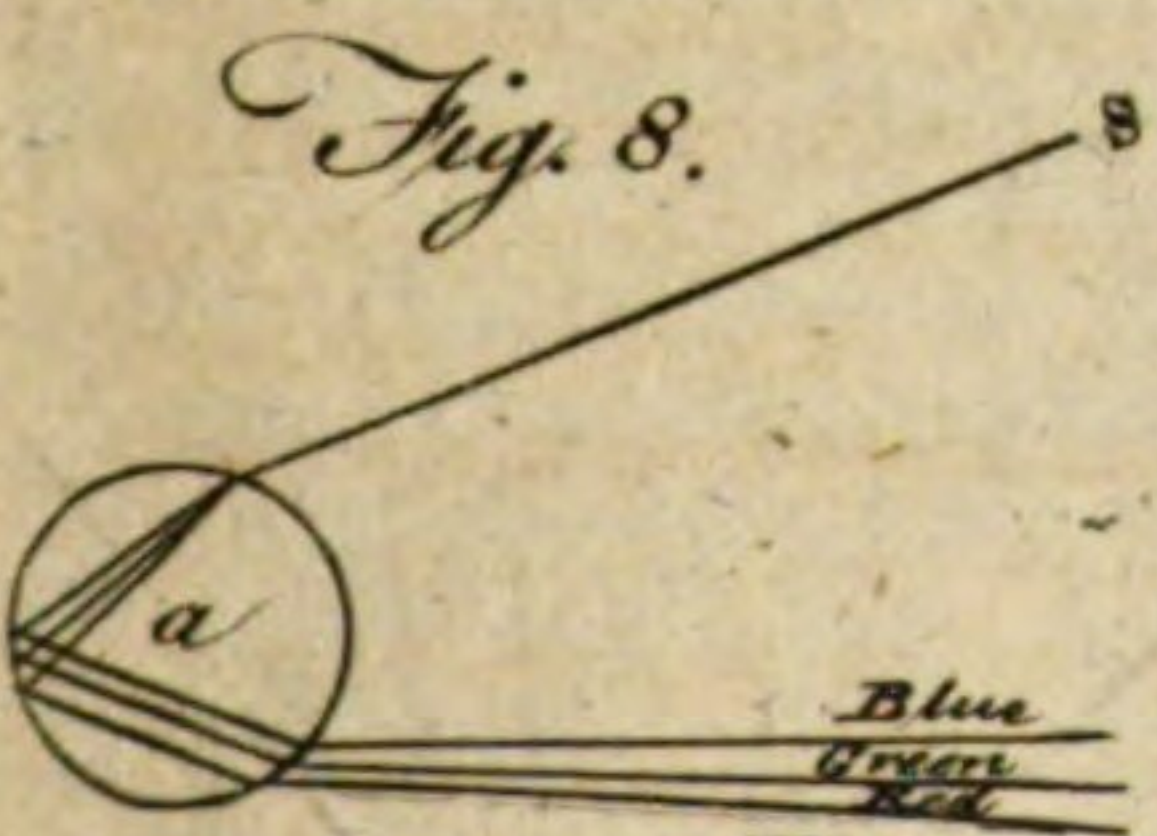
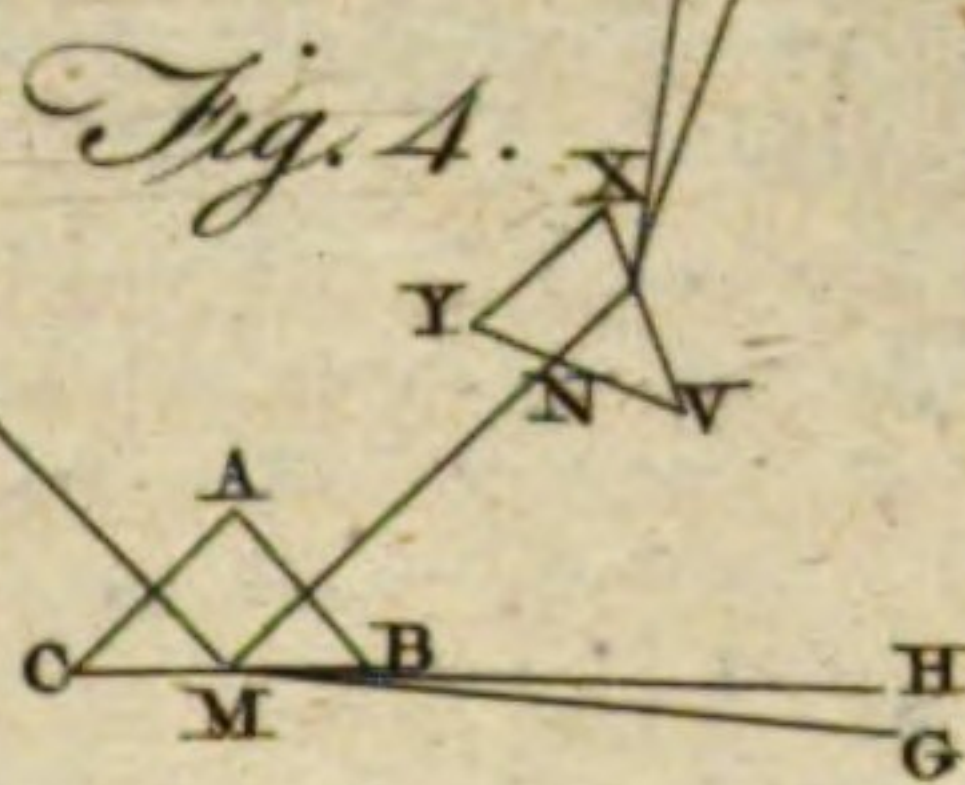
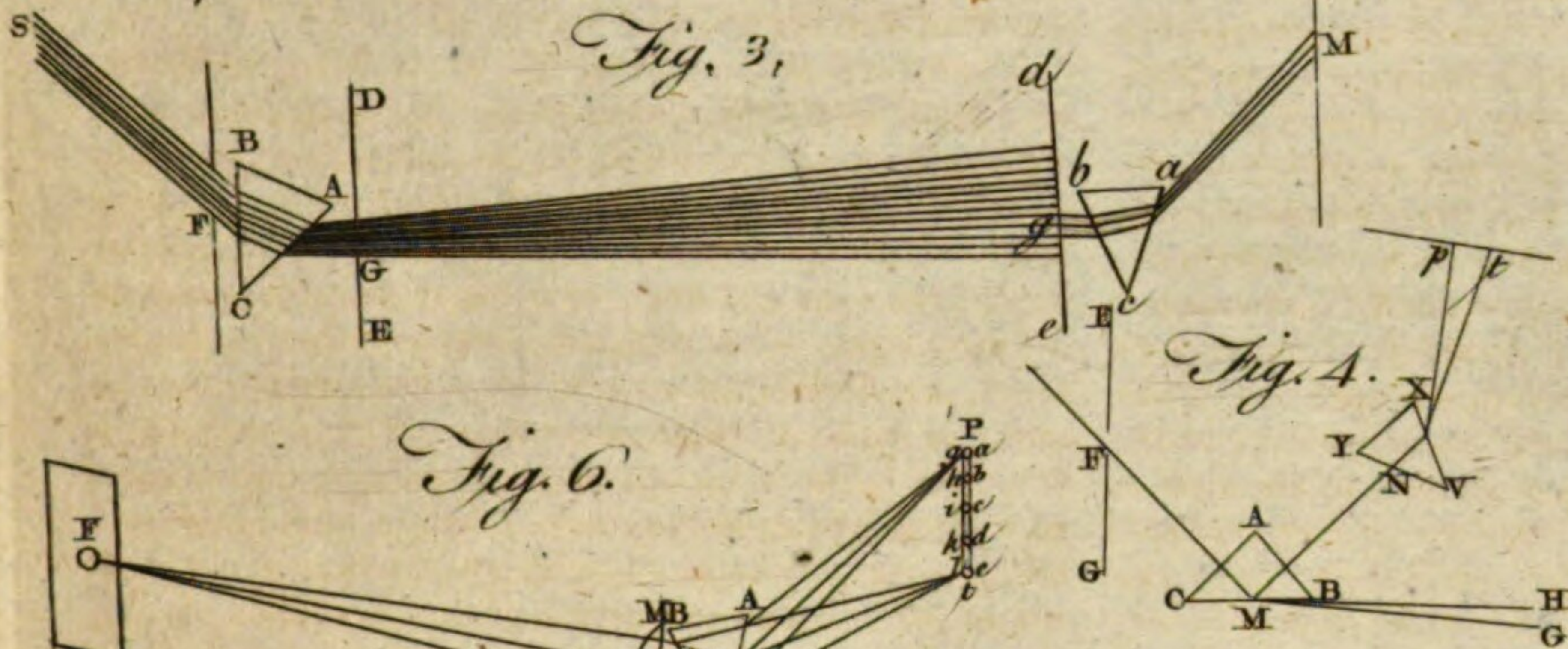
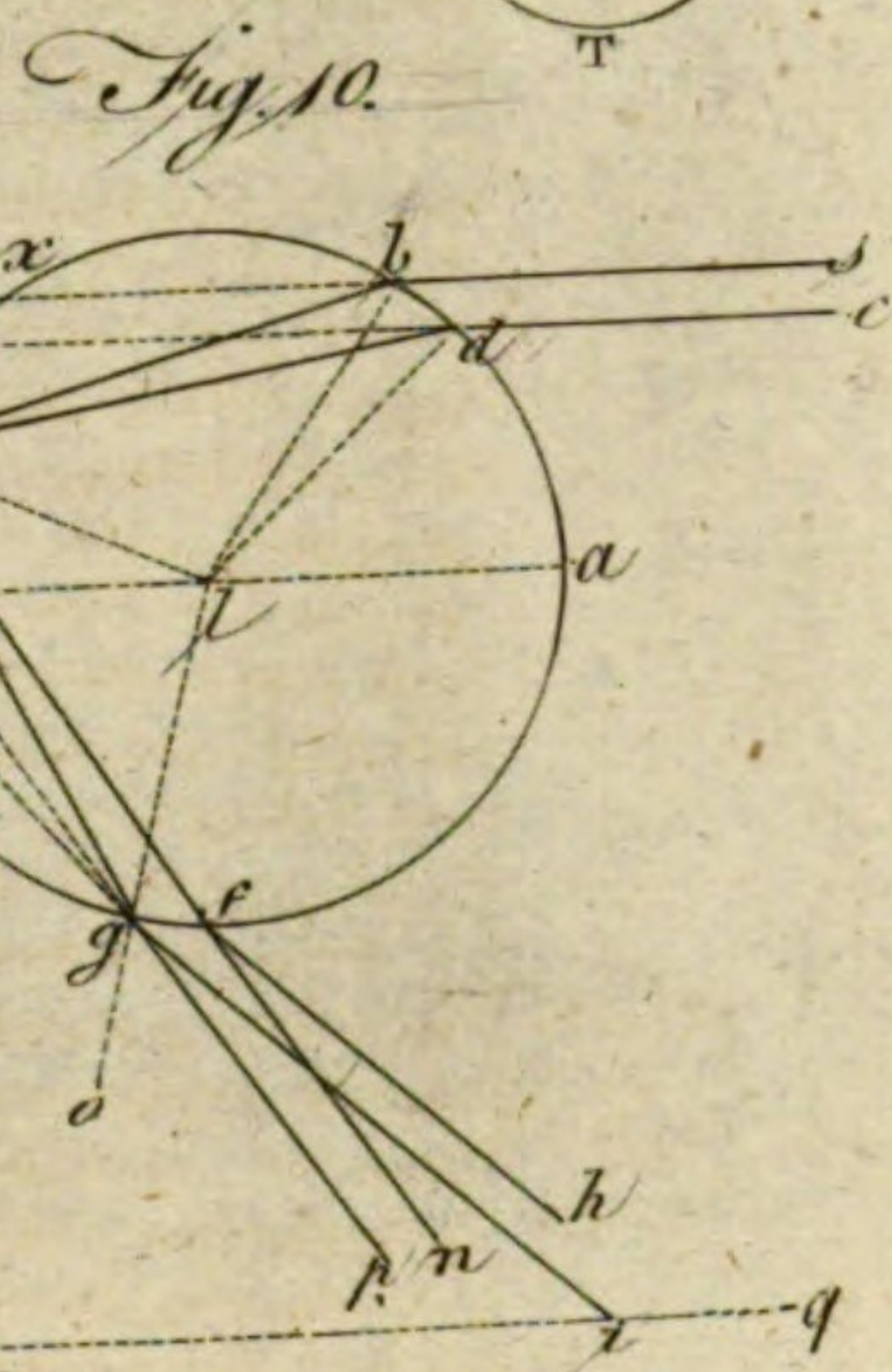
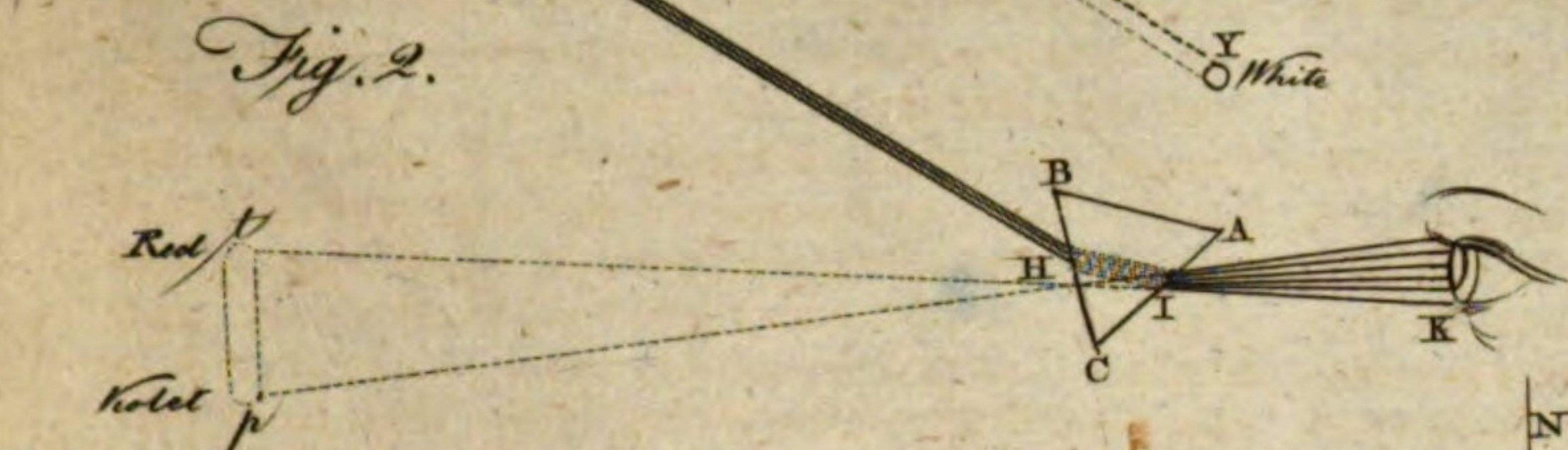
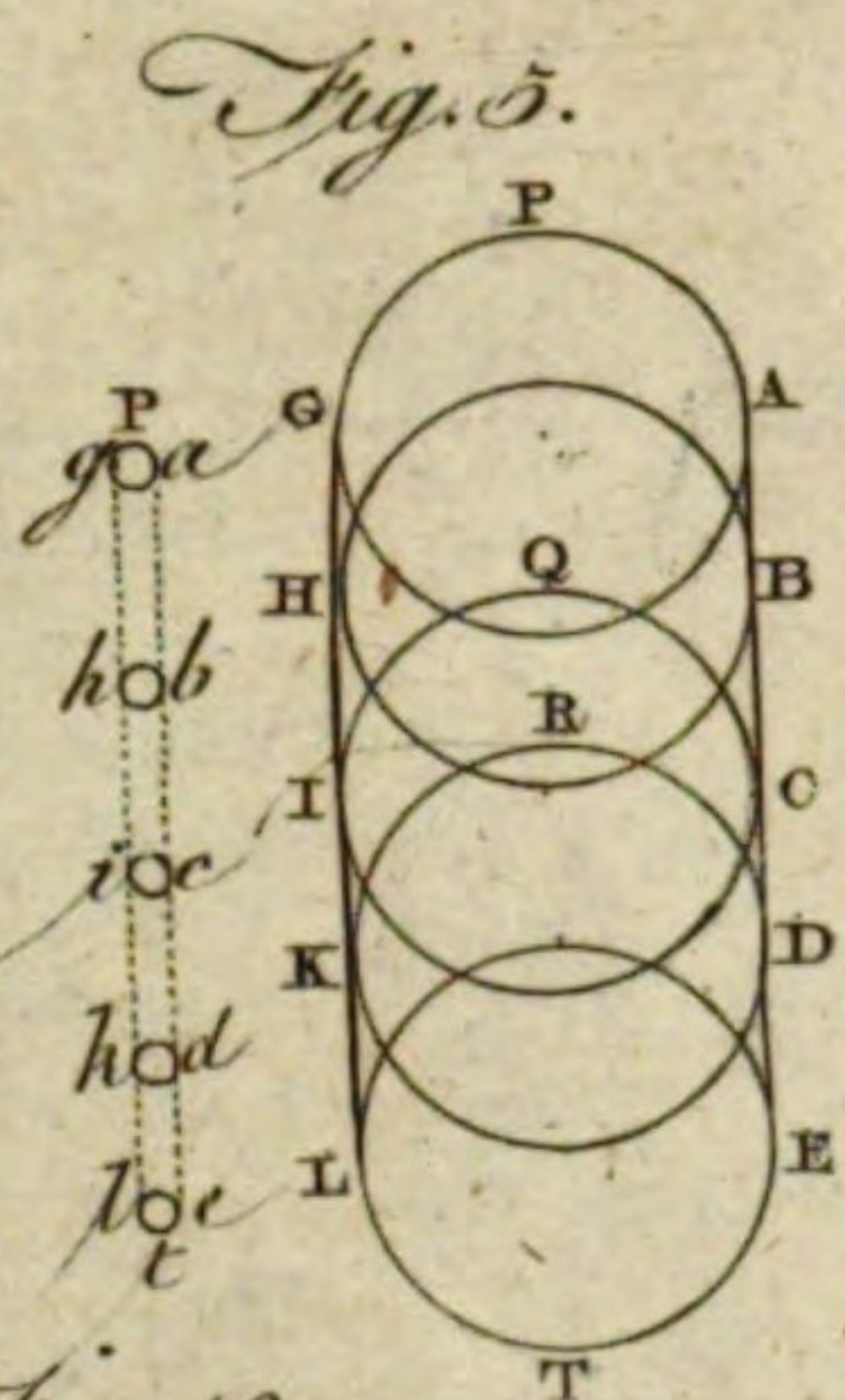
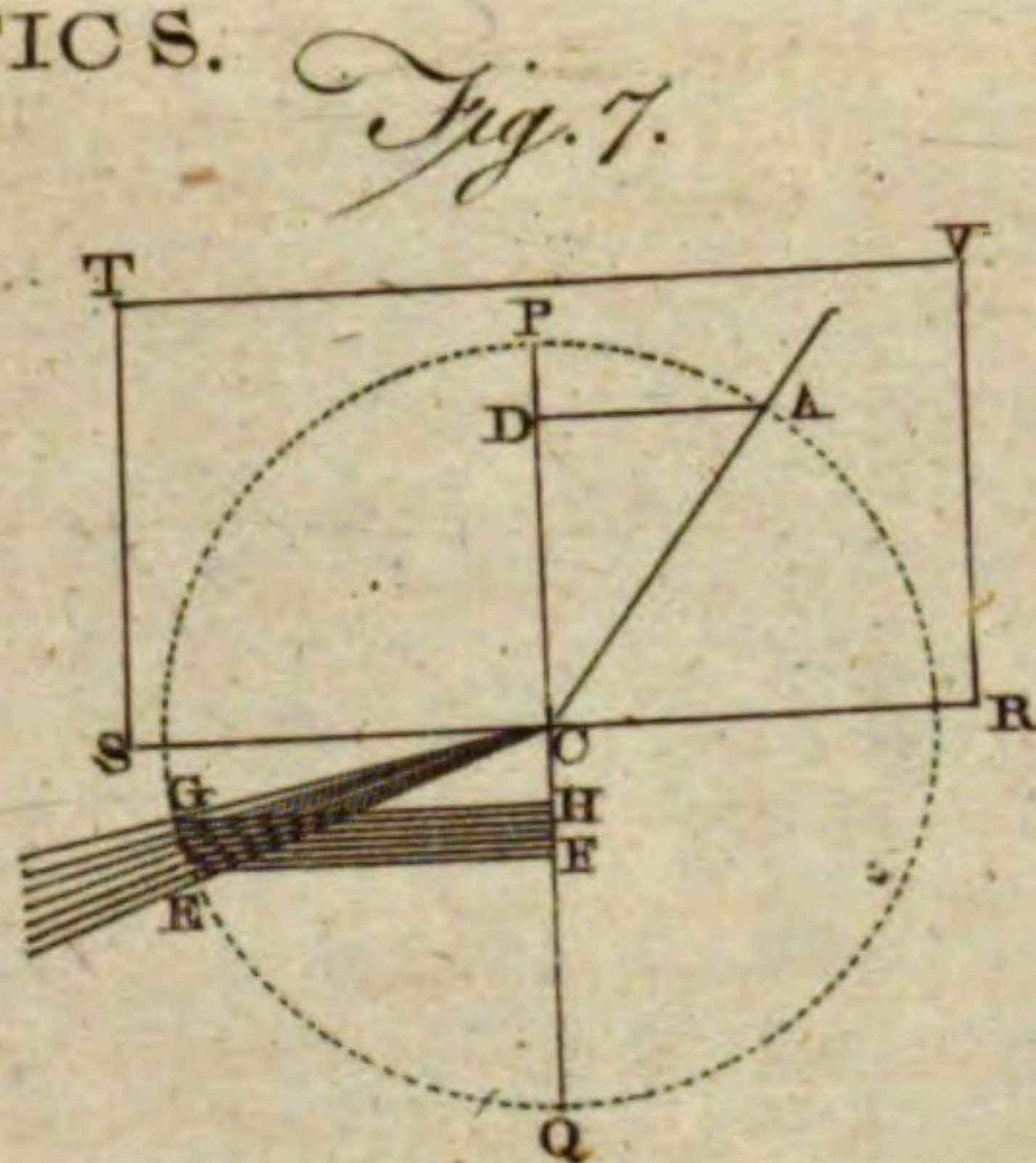
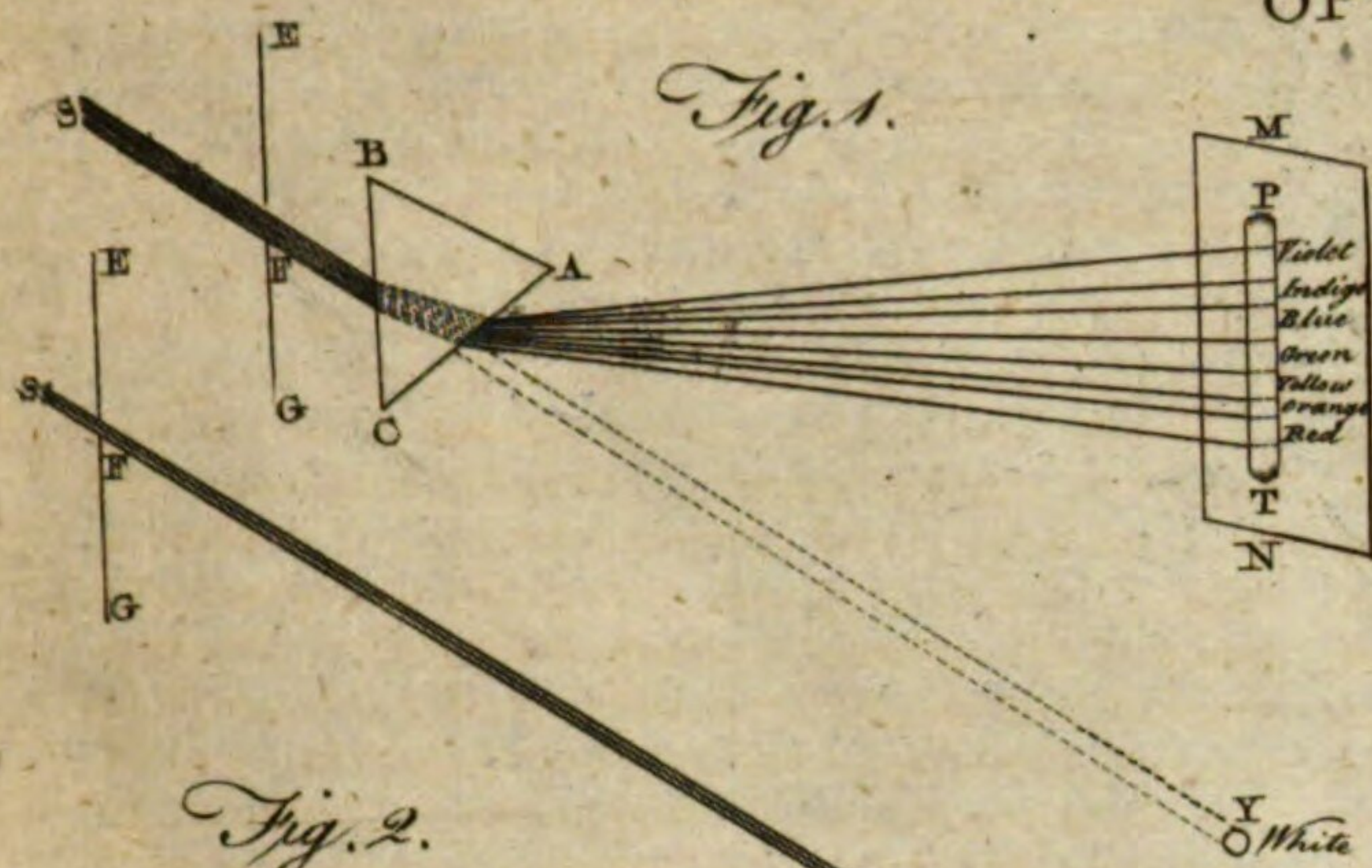
M. de la Hire first endeavoured to explain the cause of those dark spots which seem to float before the eyes, especially those of old people. They are most visible when the eyes are turned towards an uniform white object, as the snow in the open fields. If they be fixed when the eye is so, this philosopher supposed that they were occasioned by extravasated blood upon the retina. But he thought that the moveable spots were occasioned by opaque matter floating in the aqueous humour of the eye. He thought the vitreous humour was not sufficiently limpid for this purpose.

By the following calculation, M. de la Hire gives us an idea of the extreme sensibility of the optic nerves. One may see very easily, at the distance of 4000 toises, the sail of a wind-mill, 6 feet in diameter; and the eye being supposed to be an inch in diameter, the picture of this sail, at the bottom of the eye, will be $\frac{1}{8000}$ of an inch, which is less than the 666th part of a line, and is about the 66th part of a common hair, or the 8th part of a single thread of silk. So small, therefore, must one of the fibres of the optic nerve be, which he

says

The appa-
rent place
&c. of
objects.

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M. le Cat's
account of
of the
largeness of
objects in
mist.



Abell Pin. Wall. Sculptor fecit.

Apparent
place, &c.
of objects.

says is almost inconceivable, since each of these fibres is a tube that contains spirits. If birds perceive distant objects as well as men, which he thinks very probable, he observes that the fibres of their optic nerves must be much finer than ours.

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Berkeley's
account of
the judge-
ment form-
ed concern-
ing distance
by confused
vision.

The person who first took much notice of Dr Barrow's hypothesis was the ingenious Dr Berkeley, bishop of Cloyne, who distinguished himself so much by the objections which he started to the reality of a material world, and by his opposition to the Newtonian doctrine of fluxions. In his Essay towards a New Theory of Vision, he observes, that the circle formed upon the retina, by the rays which do not come to a focus, produce the same confusion in the eye, whether they cross one another before they reach the retina, or tend to do it afterwards; and therefore that the judgment concerning distance will be the same in both the cases, without any regard to the place from which the rays originally issued; so that in this case, as, by receding from the lens, the confusion, which always accompanies the nearness of an object, increases, the mind will judge that the object comes nearer.

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Smith's ac-
count.

But, says Dr Smith, if this be true, the object ought always to appear at a less distance from the eye than that at which objects are seen distinctly, which is not the case: and to explain this appearance, as well as every other in which a judgment is formed concerning distance, he maintains, that we judge of it by the apparent magnitude of objects only, or chiefly; so that, since the image grows larger as we recede from the lens through which it is viewed, we conceive the object to come nearer. He also endeavours to show, that, in all cases in which glasses are used, we judge of distance by the same simple rule; from which he concludes universally, that the apparent distance of an object seen in a glass is to its apparent distance seen by the naked eye as the apparent magnitude to the naked eye is to its apparent magnitude in the glass.

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Objected to
by Mr Ro-
bins.

But that we do not judge of distance merely by the angle under which objects are seen, is an observation as old as Alhazen, who mentions several instances, in which, though the angles under which objects appear be different, the magnitudes are universally and instantaneously deemed not to be so. And Mr Robins clearly shows the hypothesis of Dr Smith to be contrary to fact in the most common and simple cases. In microscopes, he says, it is impossible that the eye should judge the object to be nearer than the distance at which it has viewed the object itself, in proportion to the degree of magnifying. For when the microscope magnifies much, this rule would place the image at a distance, of which the sight cannot possibly form any opinion, as being an interval from the eye at which no object can be seen. In general, he says, he believes, that whoever looks at an object through a convex glass, and then at the object itself without the glass, will find it to appear nearer in the latter case, though it be magnified in the glass; and in the same trial with the concave glass, though by the glass the object be diminished, it will appear nearer through the glass than without it.

But the most convincing proof that the apparent distance of the image is not determined by its apparent magnitude, is the following experiment. If a double convex glass be held upright before some luminous

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object, as a candle, there will be seen two images, one erect, and the other inverted. The first is made simply by reflection from the nearest surface, the second by reflection from the farther surface, the rays undergoing a refraction from the first surface both before and after the reflection. If this glass has not too short a focal distance, when it is held near the object, the inverted image will appear larger than the other, and also nearer; but if the glass be carried off from the object, though the eye remain as near to it as before, the inverted image will diminish so much faster than the other, that, at length, it will appear very much less than it, but still nearer. Here, says Mr Robins, two images of the same object are seen under one view, and their apparent distances immediately compared; and here it is evident, that those distances have no necessary connection with the apparent magnitude. He also shows how this experiment may be made still more convincing, by sticking a piece of paper on the middle of the lens, and viewing it through a short tube.

M. Bouguer adopts the general maxim of Dr Barrow, in supposing that we refer objects to the place from which the pencils of rays seemingly converge at their entrance into the pupil. But when rays issue from below the surface of a vessel of water, or any other refracting medium, he finds that there are always two different places of this seeming convergence; one of them of the rays that issue from it in the same vertical circle, and therefore fall with different degrees of obliquity upon the surface of the refracting medium; and another, of those that fall upon the surface with the same degree of obliquity, entering the eye laterally with respect to one another. Sometimes, he says, one of these images is attended to by the mind, and sometimes the other, and different images may be observed by different persons. An object plunged in water affords an example, he says, of this duplicity of images.

If $BA b$ (fig. 1.) be part of the surface of water, and the object be at O , there will be two images of it in two different places; one at G , on the caustic by refraction, and the other at E , in the perpendicular AO , which is as much a caustic as the other line. The former image is visible by the rays ODM , $O d m$, which are one higher than the other, in their progress to the eye; whereas the image at E is made by the rays ODM , $O e f$, which enter the eye laterally. This, says he, may serve to explain the difficulty of Father Tacquet, Barrow, Smith, and many other authors, and which Newton himself considered as a very difficult problem, though it might not be absolutely insoluble.

G. W. Kraft has ably supported the opinion of Dr Barrow, that the place of any point, seen by reflection from the surface of any medium, is that in which rays issuing from it, infinitely near to one another, would meet; and considering the case of a distant object, viewed in a concave mirror, by an eye very near to it, when the image, according to Euclid and other writers, would be between the eye and the object, and the rule of Dr Barrow cannot be applied; he says that in this case the speculum may be considered as a plane, the effect being the same, only the image is more obscure.

T t

Dr

Apparent
place, &c.
of objects.

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M. Bou-
guer adopts
Dr Barrow's
maxim.

Plate
CCCLXL

Apparent
place, &c.
of objects.

Dr Porterfield gives a distinct and comprehensive view of the natural methods of judging concerning the distance of objects.

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Dr Porter-
field's view
of this sub-
ject.

The conformation of the eye, he observes, can be of no use to us with respect to objects that are placed without the limits of distinct vision. As the object, however, does then appear more or less confused, according as it is more or less removed from those limits, this confusion assists the mind in judging of the distance of the object; it being always esteemed so much the nearer, or the farther off, by how much the confusion is greater. But this confusion hath its limits also, beyond which it can never extend; for when an object is placed at a certain distance from the eye, to which the breadth of the pupil bears no sensible proportion, the rays of light that come from a point in the object and pass the pupil, are so little diverging, that they may be considered as parallel. For a picture on the retina will not be sensibly more confused, though the object be removed to a much greater distance.

The most universal, and frequently the most sure means of judging of the distance of objects is, he says, the angle made by the optic axis. For our two eyes are like two different stations, by the assistance of which distances are taken; and this is the reason why those persons who are blind of one eye, so frequently miss their mark in pouring liquor into a glass, snuffing a candle, and such other actions as require that the distance be exactly distinguished. To convince ourselves of the usefulness of this method of judging of the distance of objects, he directs us to suspend a ring in a thread, so that its side may be towards us and the hole in it to the right and left hand; and taking a small rod, crooked at the end, retire from the ring two or three paces, and having with one hand covered one of our eyes, to endeavour with the other to pass the crooked end of the rod through the ring. This, says he, appears very easy; and yet, upon trial, perhaps once in 100 times we shall not succeed, especially if we move the rod a little quickly.

Our author observes, that by persons recollecting the time when they began to be subject to the mistakes above-mentioned, they may tell when it was that they lost the use of one of their eyes; which many persons are long ignorant of, and which may be a circumstance of some consequence to a physician*. The use of this second method of judging of distances De Chales limited to 120 feet; beyond which, he says, we are not sensible of any difference in the angle of the optic axis.

A third method of judging of the distance of objects, consists in their apparent magnitudes, on which so much stress was laid by Dr Smith. From this change in the magnitude of the image upon the retina, we easily judge of the distance of objects, as often as we are otherwise acquainted with the magnitude of the objects themselves; but as often as we are ignorant of the real magnitude of bodies, we can never, from their apparent magnitude, form any judgment of their distance.

From this we may see why we are so frequently deceived in our estimates of distance, by any extraordinary magnitudes of objects seen at the end of it; as, in travelling towards a large city, or a castle, or a cathedral church, or a mountain larger than ordinary,

we fancy them to be nearer than we find them to be. This also is the reason why animals, and all small objects, seen in valleys, contiguous to large mountains, appear exceedingly small. For we think the mountain nearer to us than if it were smaller; and we should not be surprised at the smallness of the neighbouring animals, if we thought them farther off. For the same reason, we think them exceedingly small, when they are placed upon the top of a mountain, or a large building; which appear nearer to us than they really are, on account of their extraordinary size.

Dr Jurin clearly accounts for our imagining objects, when seen from a high building, to be smaller than they are, and smaller than we fancy them to be when we view them at the same distance on level ground. It is, says he, because we have no distinct idea of distance in that direction, and therefore judge of things by their pictures upon the eye only; but custom will enable us to judge rightly even in this case.

Let a boy, says he, who has never been upon any high building, go to the top of the monument, and look down into the street; the objects seen there, as men and horses, will appear so small as greatly to surprise him. But 10 or 20 years after, if in the mean time he has used himself now and then to look down from that and other great heights, he will no longer find the same objects to appear so small. And if he was to view the same objects from such heights as frequently as he sees them upon the same level with himself in the streets, he supposes that they would appear to him just of the same magnitude from the top of the monument, as they do from a window one story high. For this reason it is, that statues placed upon very high buildings ought to be made of a larger size than those which are seen at a nearer distance; because all persons, except architects, are apt to imagine the height of such buildings to be much less than it really is.

The fourth method by which Dr Porterfield says that we judge of the distance of objects, is the force with which their colour strikes upon our eyes. For if we be assured that two objects are of a similar and like colour, and that one appears more bright and lively than the other, we judge that the brighter object is the nearer of the two.

The fifth method consists in the different appearance of the small parts of objects. When these parts appear distinct, we judge that the object is near; but when they appear confused, or when they do not appear at all, we judge that it is at a greater distance. For the image of any object, or part of an object, diminishes as the distance of it increases.

The sixth and last method by which we judge of the distance of objects is, that the eye does not represent to our mind one object alone, but at the same time all those that are placed betwixt us and the principal object, whose distance we are considering; and the more this distance is divided into separate and distinct parts, the greater it appears to be. For this reason, distances upon uneven surfaces appear less than upon a plane: for the inequalities of the surfaces, such as hills, and holes, and rivers, that lie low and out of sight, either do not appear, or hinder the parts that lie behind them from appearing; and so the whole apparent distance is diminished by the parts that do not

* See
Medicine,
n^o 360.

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place, &c.
of objects.

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Why objects
seen from
a high
building ap-
pear smaller
than they
are.

Apparent
place, &c.
of objects.

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Several fal-
lacies of vi-
sion ex-
plained.

not appear in it. This is the reason that the banks of a river appear contiguous to a distant eye, when the river is low and not seen.

Dr Porterfield very well explains several fallacies in vision depending upon our mistaking the distances of objects. Of this kind, he says, is the appearance of parallel lines, and long vistas consisting of parallel rows of trees; for they seem to converge more and more as they are farther extended from the eye. The reason of this, he says, is because the apparent magnitudes of their perpendicular intervals are perpetually diminishing, while, at the same time, we mistake their distance. Hence we may see why, when two parallel rows of trees stand upon an ascent, whereby the more remote parts appear farther off than they really are, because the line that measures the length of the vistas now appears under a greater angle than when it was horizontal, the trees, in such a case, will seem to converge less, and sometimes, instead of converging, they will be thought to diverge.

For the same reason that a long vista appears to converge more and more the farther it is extended from the eye, the remoter parts of a horizontal walk or a long floor will appear to ascend gradually; and objects placed upon it, the more remote they are the higher they will appear, till the last be seen on a level with the eye; whereas the ceiling of a long gallery appears to descend towards a horizontal line, drawn from the eye of the spectator. For this reason, also, the surface of the sea, seen from an eminence, seems to rise higher and higher the farther we look; and the upper parts of high buildings seem to stoop, or incline forwards over the eye below, because they seem to approach towards a vertical line proceeding from the spectator's eye; so that statues on the top of such buildings, in order to appear upright, must recline, or bend backwards.

Our author also shows the reason why a windmill, seen from a great distance, is sometimes imagined to move the contrary way from what it really does, by our taking the nearer end of the sail for the more remote. The uncertainty we sometimes find in the course of the motion of a branch of lighted candles, turned round at a distance, is owing, he says, to the same cause; as also our sometimes mistaking a convex for a concave surface, more especially in viewing seals and impressions with a convex glass or a double microscope; and lastly, that, upon coming in a dark night into a street, in which there is but one row of lamps, we often mistake the side of the street they are on.

Far more light was thrown upon this curious subject by M. Bouguer.

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Great light
thrown up-
on this sub-
ject by M.
Bouguer.

The proper method of drawing the appearance of two rows of trees that shall appear parallel to the eye, is a problem which has exercised the ingenuity of several philosophers and mathematicians. That the apparent magnitude of objects decreases with the angle under which they are seen, has always been acknowledged. It is also acknowledged, that it is only by custom and experience that we learn to form a judgment both of magnitudes and distances. But in the application of these maxims to the above-mentioned problem, all persons, before M. Bouguer, made use of the real distance instead of the apparent one; by

which only the mind can form its judgment. And it is manifest, that, if any circumstances contribute to make the distance appear otherwise than it is in reality, the apparent magnitude of the object will be affected by it; for the same reason, that, if the magnitude be misapprehended, the idea of the distance will vary.

For want of attending to this distinction, Tacquet pretended to demonstrate, that nothing can give the idea of two parallel lines (rows of trees for instance) to an eye situated at one of their extremities, but two hyperbolic curves, turned the contrary way; and M. Varignon maintained, that in order to make a vista appear of the same width, it must be made narrower, instead of wider, as it recedes from the eye.

M. Bouguer observes, that very great distances, and those that are considerably less than they, make nearly the same impression upon the eye. We, therefore, always imagine great distances to be less than they are; and for this reason the ground plan of a long vista always appears to rise. The visual rays come in a determinate direction; but as we imagine that they terminate sooner than they do, we necessarily conceive that the place from which they issue is elevated. Every large plane, therefore, as AB, (fig. 2.) viewed by an eye at O, will seem to lie in such a direction as *Ab*; and consequently lines, in order to appear truly parallel on the plane AB, must be drawn so as that they would appear parallel on the plane *Ab*, and be from thence projected to the plane AB.

Plate
CCCLXI.

To determine the inclination of the apparent ground-plan *Ab* to the true ground-plan AB, our ingenious author directs us to draw upon a piece of level ground two straight lines of a sufficient length (for which purpose lines fastened to small sticks are very convenient), making an angle of 3 or 4 degrees with one another. Then a person, placing himself within the angle, with his back towards the angular point, must walk backwards and forwards till he can fancy the lines to be parallel. In this situation, a line drawn from the point of the angle thro' the place of his eye, will contain the same angle with the true ground-plan which this does with the apparent one.

M. Bouguer then shows other more geometrical methods of determining this inclination; and says, that by these means he has often found it to be 4 or 5 degrees, though sometimes only 2 or $2\frac{1}{2}$ degrees. The determination of this angle, he observes, is variable; depending upon the manner in which the ground is illuminated and the intensity of the light. The colour of the soil is also not without its influence, as well as the particular conformation of the eye, by which it is more or less affected by the same degree of light, and also the part of the eye on which the object is painted. When, by a slight motion of his head, he contrived, that certain parts of the soil, the image of which fell towards the bottom of his eye, should fall towards the top of the retina, he always thought that this apparent inclination became a little greater.

But what is very remarkable, and what he says he can assure his reader may be depended upon, is, that if he look towards a rising ground, the difference between the apparent ground-plan and the true one will be much more considerable, so that they will sometimes make an angle of 25 or 30 degrees. Of this he

Apparent
place, &c.
of objects.

Apparent
place, &c.
of objects.

had made frequent observations. Mountains, he says, begin to be inaccessible when their sides make an angle from 35 to 37 degrees with the horizon, as then it is not possible to climb them but by means of stones or shrubs, to serve as steps to fix the feet on. In these cases, both he and his companions always agreed that the apparent inclination of the side of the mountain was 60 or 70 degrees.

Plate
CCCLXI.

These deceptions are represented in fig. 3. in which, when the ground plan AM, or AN, are much inclined, the apparent ground-plan Am, or An, makes a very large angle with it. On the contrary, if the ground dips below the level, the inclination of the apparent to the true ground-plan diminishes, till, at a certain degree of the slope, it becomes nothing at all; the two plans AP and Ap being the same, so that parallel lines drawn upon them would always appear so. If the inclination below the horizon is carried beyond the situation AP, the error will increase; and what is very remarkable, it will be on the contrary side; the apparent plan Ar being always below the true plan AR, so that if a person would draw upon the plan AR lines that shall appear parallel to the eye, they must be drawn converging, and not diverging, as is usual on the level ground; because they must be the projections of two lines imagined to be parallel, on the plan Ar, which is more inclined to the horizon than AR.

These remarks, he observes, are applicable to different planes exposed to the eye at the same time. For if BH, fig. 4. be the front of a building, at the distance of AB from the eye, it will be reduced in appearance to the distance Ab; and the front of the building will be bb, rather inclined towards the spectator, unless the distance be inconsiderable.

After making a great number of observations upon this subject, our author concludes, that when a man stands upon a level plane, it does not seem to rise sensibly but at some distance from him. The apparent plane, therefore, has a curvature in it, at that distance, the form of which is not very easy to determine; so that a man standing upon a level plane, of infinite extent, will imagine that he stands in the centre of a basin. This is also, in some measure, the case with a person standing upon the level of the sea.

He concludes with observing, that there is no difficulty in drawing lines according to these rules, so as to have any given effect upon the eye, except when some parts of the prospect are very near the spectator, and others very distant from him; because, in this case, regard must be had to the conical or conoidal figure of a surface. A right line passing at a small distance from the observer, and below the level of his eye, in that case almost always appears sensibly curved at a certain distance from the eye; and almost all figures in this case are subject to some complicated optical alteration to which the rules of perspective have not as yet been extended. If a circle be drawn near our feet, and within that part of the ground which appears level to us, it will always appear to be a circle, and at a very considerable distance it will appear an ellipse; but between these two situations, it will not appear to be either the one or the other, but will be like one of those ovals of Descartes, which is more curved on one of its sides than the other.

On these principles a parterre, which appears dis-

torted when it is seen in a low situation, appears perfectly regular when it is viewed from a balcony or any other eminence. Still, however, the apparent irregularity takes place at a greater distance, while the part that is near the spectator is exempt from it. If AB, fig. 5. be the ground plane, and Aa be a perpendicular, under the eye, the higher it is situated, at O, to the greater distance will T, the place at which the plane begins to have an apparent ascent along Tb, be removed.

All the varieties that can occur with respect to the visible motion of objects, are thus succinctly summed up by Dr Porterfield under eleven heads.

1. An object moving very swiftly is not seen, unless it be very luminous. Thus a cannon-ball is not seen if it is viewed transversely: but if it be viewed according to the line it describes, it may be seen, because its picture continues long on the same place of the retina; which, therefore, receives a more sensible impression from the object.

2. A live coal swung briskly round in a circle appears a continued circle of fire, because the impressions made on the retina by light, being of a vibrating, and consequently of a lasting nature, do not presently perish, but continue till the coal performs its whole circuit, and returns again to its former place.

3. If two objects, unequally distant from the eye, move with equal velocity, the more remote one will appear the slower; or, if their celerities be proportional to their distances, they will appear equally swift.

4. If two objects, unequally distant from the eye, move with unequal velocities in the same direction, their apparent velocities are in a ratio compounded of the direct ratio of their true velocities, and the reciprocal one of their distances from the eye.

5. A visible object moving with any velocity appears to be at rest, if the space described in the interval of one second be imperceptible at the distance of the eye. Hence it is that a near object moving very slowly, as the index of a clock, or a remote one very swiftly, as a planet, seems to be at rest.

6. An object moving with any degree of velocity will appear at rest, if the space it runs over in a second of time be to its distance from the eye as 1 to 1400.

7. The eye proceeding straight from one place to another, a lateral object, not too far off, whether on the right or left, will seem to move the contrary way.

8. The eye proceeding straight from one place to another, and being sensible of its motion, distant objects will seem to move the same way, and with the same velocity. Thus, to a person running eastwards, the moon on his right hand appears to move the same way, and with equal swiftness; for, by reason of its distance, its image continues fixed upon the same place of the retina, from whence we imagine that the object moves along with the eye.

9. If the eye and the object move both the same way, only the eye much swifter than the object, the last will appear to go backwards.

10. If two or more objects move with the same velocity, and a third remain at rest, the moveable ones will appear fixed, and the quiescent in motion the

contrary.

Apparent
place, &c.
of objects.

contrary way. Thus clouds moving very swiftly, their parts seem to preserve their situation, and the moon to move the contrary way.

11. If the eye be moved with great velocity, lateral objects at rest appear to move the contrary way. Thus to a person sitting in a coach, and riding briskly through a wood, the trees seem to retire the contrary way; and to people in a ship, &c. the shores seem to recede.

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Dr Porter-
field's ac-
count of ob-
jects ap-
pearing to
move to a
giddy per-
son when he
and they
are both at
rest.

At the conclusion of these observations, our author endeavours to explain another phenomenon of motion, which, though very common and well known, had not, as far as he knew, been explained in a satisfactory manner. It is this: If a person turns swiftly round, without changing his place, all objects about will seem to move round in a circle the contrary way; and this deception continues not only while the person himself moves round, but, which is more surprising, it also continues for some time after he ceases to move, when the eye, as well as the object, is at absolute rest.

The reason why objects appear to move round the contrary way, when the eye turns round, is not so difficult to explain: for though, properly speaking, motion is not seen, as not being in itself the immediate object of sight; yet by the sight we easily know when the image changes its place on the retina, and thence conclude that either the object, the eye, or both, are moved. But by the sight alone we can never determine how far this motion belongs to the object, how far to the eye, or how far to both. If we imagine the eye at rest, we ascribe the whole motion to the object, though it be truly at rest. If we imagine the object at rest, we ascribe the whole motion to the eye, though it belongs entirely to the object; and when the eye is in motion, though we are sensible of its motion, yet, if we do not imagine that it moves so swiftly as it really does, we ascribe only a part of the motion to the eye, and the rest of it we ascribe to the object, though it be truly at rest. This last, he says, is what happens in the present case, when the eye turns round; for though we are sensible of the motion of the eye, yet we do not apprehend that it moves so fast as it really does; and therefore the bodies about appear to move the contrary way, as is agreeable to experience.

But the great difficulty still remains, viz. Why, after the eye ceases to move, objects should, for some time, still appear to continue in motion, though their pictures on the retina be truly at rest, and do not at all change their place. This, he imagined, proceeds from a mistake we are in with respect to the eye, which, though it be absolutely at rest, we nevertheless conceive as moving the contrary way to that in which it moved before; from which mistake, with respect to the motion of the eye, the objects at rest will appear to move the same way which the eye is imagined to move; and, consequently, will seem to continue their motion for some time after the eye is at rest.

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Dr Wells
accounts
for this phe-
nomenon.

This is ingenious, but perhaps not just. An account of this matter, which seems to us more satisfactory, has been lately given to the public by Dr Wells. "Some of the older writers upon optics (says this able philosopher) imagined the visive spirits to be contained in the head, as water is in a

vessel; which, therefore, when once put in motion by the rotation of our bodies, must continue in it for some time after this has ceased; and to this real circular movement of the visive spirits, while the body is at rest, they attributed the apparent motions of objects in giddiness. Dechales saw the weakness of this hypothesis; and conjectured, that the phenomenon might be owing to a real movement of the eyes; but produced no fact in proof of his opinion. Dr Porterfield, on the contrary, supposed the difficulty of explaining it to consist in showing, why objects at rest appear in motion to an eye which is also at rest. The solution he offered of this representation of the phenomenon, is not only extremely ingenious, but is I believe the only probable one which can be given. It does not apply, however, to the fact which truly exists; for I shall immediately show, that the eye is not at rest, as he imagined. The last author I know of who has touched upon this subject is Dr Darwin. His words are, 'When any one turns round rapidly on one foot till he becomes dizzy, and falls upon the ground, the spectra of the ambient objects continue to present themselves in rotation, or appear to librate, and he seems to behold them for some time in motion.' I do not indeed pretend to understand his opinion fully; but this much seems clear, that if such an apparent motion of the surrounding objects depends in any way upon their spectra, or the illusive representations of those objects, occasioned by their former impressions upon the retinas, no similar motion would be observed, were we to turn ourselves round with our eyes shut, and not to open them till we became giddy; for in this case, as the surrounding objects could not send their pictures to the retinas, there would consequently be no spectra to present themselves afterward in rotation. But whoever will make the experiment, will find, that objects about him appear to be equally in motion, when he has become giddy by turning himself round, whether this has been done with his eyes open or shut. I shall now venture to propose my own opinion upon this subject.

"If the eye be at rest, we judge an object to be in motion when its picture falls in succeeding times upon different parts of the retina; and if the eye be in motion, we judge an object to be at rest, as long as the change in the place of its picture upon the retina holds a certain correspondence with the change of the eye's position. Let us now suppose the eye to be in motion, while, from some disorder in the system of sensation, we are either without those feelings which indicate the various positions of the eye, or are not able to attend to them. It is evident, that in such a state of things an object at rest must appear to be in motion, since it sends in succeeding times its picture to different parts of the retina. And this seems to be what happens in giddiness. I was first led to think so from observing, that, during a slight fit of giddiness I was accidentally seized with, a coloured spot, occasioned by looking steadily at a luminous body, and upon which I happened at that moment to be making an experiment, was moved in a manner altogether independent of the positions I conceived my eyes to possess. To determine this point, I again produced the spot, by looking some time at the flame of a candle: then turning myself round till I became giddy, I suddenly discontinued this motion, and directed my eyes

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Upon what
data we
judge visi-
ble objects
to be in
motion or
at rest.

to.

Apparent
place, &c.
of objects.

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Curious ex-
periments
to ascertain
this.

to the middle of a sheet of paper, fixed upon the wall of my chamber. The spot now appeared upon the paper, but only for a moment; for it immediately after seemed to move to one side, and the paper to the other, notwithstanding I conceived the position of my eyes to be in the mean while unchanged. To go on with the experiment, when the paper and spot had proceeded to a certain distance from each other, they suddenly came together again; and this separation and conjunction were alternately repeated a number of times, the limits of the separation gradually becoming less, till at length the paper and spot both appeared to be at rest, and the latter to be projected upon the middle of the former. I found also, upon repeating and varying the experiment a little, that when I had turned myself from left to right, the paper moved from right to left, and the spot consequently the contrary way; but that when I had turned from right to left, the paper would then move from left to right. These were the appearances observed while I stood erect. When I inclined, however, my head in such a manner as to bring the side of my face parallel to the horizon, the spot and paper would then move from each other, one upward and the other downward. But all these phenomena demonstrate, that there was a real motion in my eyes at the time I imagined them to be at rest; for the apparent situation of the spot, with respect to the paper, could not possibly have been altered, without a real change of the position of those organs. To have the same thing proved in another way, I desired a person to turn quickly round, till he became very giddy; then to stop himself, and look stedfastly at me. He did so, and I could plainly see, that although he thought his eyes were fixed, they were in reality moving in their sockets, first toward one side and then toward the other."

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A remark-
able decep-
tion ex-
plained by
M. le Cat.
Plate
CCCLXI.

M. Le Cat well explains a remarkable deception, by which a person shall imagine an object to be on the opposite side of a board, when it is not so, and also inverted and magnified. It is illustrated by fig. 6. in which D represents the eye, and CB a large black board, pierced with a small hole. E is a large white board, placed beyond it, and strongly illuminated; and *d* a pin, or other small object, held betwixt the eye and the first board. In these circumstances, the pin shall be imagined to be at F, on the other side of the board, where it will appear inverted and magnified; because what is in fact perceived, is the shadow of the pin upon the retina; and the light that is stopped by the upper part of the pin coming from the lower part of the enlightened board, and that which is stopped by the lower part coming from the upper part of the board, the shadow must necessarily be inverted with respect to the object.

There is a curious phenomenon relating to vision, which some persons have ascribed to the inflection of light, but which Mr Melville explains in a very different and very simple manner.

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A curious
phenome-
non explain-
ed by Mr
Melville.

When any opaque body is held at the distance of three or four inches from the eye, so that a part of some more distant luminous object, such as the window, or the flame of a candle, may be seen by rays passing near its edge, if another opaque body, nearer to the eye, be brought across from the opposite side, the edge of the first body will seem to swell out-

wards, and meet the latter; and in doing so will intercept a portion of the luminous object that was seen before.

Concavity
of the Sky.

This appearance he explains in the following manner: Let AB (fig. 7.) represent the luminous object to which the sight is directed, CD the more distant opaque body, GH the nearer, and EF the diameter of the pupil. Join ED, FD, EG, FG, and produce them till they meet AB in K, N, M, and L. It is plain that the parts AN, MB, of the luminous object cannot be seen. But taking any point *a* between N and K, and drawing *a* D *d*, since the portion *d* F of the pupil is filled with light flowing from that point, it must be visible. Any point *b*, between *a* and K, must fill *f* F, a greater portion of the pupil, and therefore must appear brighter. Again, any point *c*, between *b* and K, must appear brighter than *b*, because it fills a greater portion *g* F with light. The point K itself, and every other point in the space KL, must appear very luminous, since they send entire pencils of rays EKF, ELF, to the eye; and the visible brightness of every point from L towards M, must decrease gradually, as from K to N; that is, the spaces KN, LM, will appear as dim shadowy borders, or fringes, adjacent to the edges of the opaque bodies.

When the edge G is brought to touch the right line KF, the penumbras unite; and as soon as it reaches NDF, the above phenomenon begins; for it cannot pass that right line without meeting some line *a* D *d*, drawn from a point between N and K, and, by intercepting all the rays that fall upon the pupil, render it invisible. In advancing gradually to the line KDE, it will meet other lines *b* D *f*, *c* D *g*, &c. and therefore render the points *b*, *c*, &c. from N to K, successively invisible; and therefore the edge of the fixed opaque body CD must seem to swell outwards, and cover the whole space NK; while GH, by its motion, covers MK. When GH is placed at a greater distance from the eye, CD continuing fixed, the space OP to be passed over in order to intercept NK is less; and therefore, with an equal motion of GH, the apparent swelling of CD must be quicker; which is found true by experience.

If ML represent a luminous object, and REFQ any plane exposed to its light, the space FQ will be entirely shaded from the rays, and the space FE will be occupied by a penumbra, gradually darker, from E to F. Let now GH continue fixed, and CD move parallel to the plane EF; and as soon as it passes the line LF, it is evident that the shadow QF will seem to swell outwards; and when CD reaches ME, so as to cover with its shadow the space RE, QF, by its extension, will cover FE. This is found to hold true likewise by experiment.

§ 4. Of the Concave Figure of the Sky.

THIS apparent concavity is only an optical deception founded on the incapacity of our organs of vision to take in very large distances.—Dr Smith, in his Complete System of Optics, hath demonstrated, that, if the surface of the earth was perfectly plane, the distance of the visible horizon from the eye would scarce exceed the distance of 5000 times the height of the eye above the ground, supposing the height of the eye between five and six feet: beyond this distance,

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Extent of
the visible
horizon on
a plane
surface.

Concavity
of the Sky.Plate
CCCLXI.
fig. 8.

all objects would appear in the visible horizon. For, let OP be the height of the eye above the line PA drawn upon the ground; and if an object AB , equal in height to PO , be removed to a distance PA equal to 5000 times that height, it will hardly be visible by reason of the smallness of the angle AOB . Consequently any distance AC , how great soever, beyond A , will be invisible. For since AC and BO are parallel, the ray CO will always cut AB in some point D between A and B ; and therefore the angle AOC , or AOD , will always be less than AOB , and therefore AD or AC will be invisible. Consequently all objects and clouds, as CE and FG , placed at all distances beyond A , if they be high enough to be visible, or to subtend a bigger angle at the eye than AOB , will appear at the horizon AB ; because the distance AC is invisible.

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Why a long
row of ob-
jects ap-
pears circu-
lar.

Hence, if we suppose a vast long row of objects, or a vast long wall $ABZY$ (fig. 9.), built upon this plane, and its perpendicular distance OA from the eye at O to be equal to or greater than the distance Oa of the visible horizon, it will not appear straight, but circular, as if it was built upon the circumference of the horizon $acegy$: and if the wall be continued to an immense distance, its extreme parts YZ will appear in the horizon at yz , where it is cut by a line Oy parallel to the wall. For, supposing a ray YO , the angle YOy will become insensibly small. Imagine this infinite plane $OAYy$, with the wall upon it, to be turned about the horizontal line O like the lid of a box, till it becomes perpendicular to the other half of the horizontal plane LMy , and the wall parallel to it, like a vast ceiling over head; and then the wall will appear like the concave figure of the clouds overhead. But though the wall in the horizon appear in the figure of a semicircle, yet the ceiling will not, but much flatter. Because the horizontal plane was a visible surface, which suggested the idea of the same distances quite round the eye: but in the vertical plane extended between the eye and the ceiling, there is nothing that affects the sense with an idea of its parts but the common line Oy ; consequently the apparent distances of the higher parts of the ceiling will be gradually diminished in ascending from that line. Now when the sky is quite overcast with clouds of equal gravities, they will all float in the air at equal heights above the earth, and consequently will compose a surface resembling a large ceiling, as flat as the visible surface of the earth. Its concavity therefore is not real, but apparent: and when the heights of the clouds are unequal, since their real shapes and magnitudes are all unknown, the eye can seldom distinguish the unequal distances of those clouds that appear in the same directions, unless when they are very near us, or are driven by contrary currents of the air. So that the visible shape of the whole surface remains alike in both cases. And when the sky is either partly overcast, or partly free from clouds, it is matter of fact that we retain much the same idea of its concavity as when it was quite overcast.

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Why the
concavity
of the sky
appears less
than a he-
misphere.

The concavity of the heavens appears to the eye, which is the only judge of an apparent figure, to be a less portion of a spherical surface than a hemisphere. Dr Smith says, that the centre of the concavity is much below the eye; and by taking a medium among

several observations, he found the apparent distance of its parts at the horizon to be generally between three and four times greater than the apparent distance of its parts overhead. For let the arch $ABCD$ represent the apparent concavity of the sky, O the place of the eye, OA and OC the horizontal and vertical apparent distances, whose proportion is required. First observe when the sun or the moon, or any cloud or star, is in such a position at B , that the apparent arches BA , BC , extended on each side of this object towards the horizon and zenith, seem equal to the eye; then taking the altitude of the object B with a quadrant, or a cross-staff, or finding it by astronomy from the given time of observation, the angle AOB is known. Drawing therefore the line OB in the position thus determined, and taking in it any point B at pleasure, in the vertical line CO produced downwards, seek the centre E of a circle ABC , whose arches BA , BC , intercepted between B and the legs of the right angle AOC , shall be equal to each other; then will this arch $ABCD$ represent the apparent figure of the sky. For by the eye we estimate the distance between any two objects in the heavens by the quantity of sky that appears to lie between them; as upon earth we estimate it by the quantity of ground that lies between them. The centre E may be found geometrically by constructing a cubic equation, or as quickly and sufficiently exact by trying whether the chords BA , BC , of the arch ABC drawn by conjecture are equal, and by altering its radius BE till they are so. Now in making several observations upon the sun, and some others upon the moon and stars, they seemed to our author to bisect the vertical arch ABC at B , when their apparent altitudes or the angle AOB was about 23 degrees; which gives the proportion of OC to OA as 3 to 10 or as 1 to $3\frac{1}{3}$ nearly. When the sun was but 30 degrees high, the upper arch seemed always less than the under one; and, in our author's opinion, always greater when the sun was about 18 or 20 degrees high.

§ 5. Of the Blue Colour of the Sky, and of Blue and Green Shadows.

The opinions of ancient writers concerning the colour of the sky merit no notice. The first who gave any rational explanation was Fromondus. By him it was supposed, that the blueness of the sky proceeded from a mixture of the white light of the sun with the black space beyond the atmosphere, where there is neither refraction nor reflection. This opinion prevailed very generally even in modern times, and was maintained by Otto Guericke and all his contemporaries, who asserted that white and black may be mixed in such a manner as to make a blue. Mr Bouguer had recourse to the vapours diffused through the atmosphere, to account for the reflection of the blue rays rather than any other. He seems however to suppose, that it arises from the constitution of the air itself, whereby the fainter coloured rays are incapable of making their way through any considerable tract of it. Hence he is of opinion, that the colour of the air is properly blue; to which opinion Dr Smith seems also to have inclined.

To this blue colour of the sky is owing the appearance of blue and green shadows in the mornings and evenings.

Blue colour
of the Sky.
Fig. 10.230
Opinions of
the ancients
respecting
the colour
of the sky.

Blue colour
of the Sky.

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Green sha-
dows obser-
ved by
M. Buffon.

evenings.—These were first taken notice of by M. Buffon in the month of July 1742, when he observed that the shadows of trees which fell upon a white wall were green. He was at that time standing upon an eminence, and the sun was setting in the cleft of a mountain, so that he appeared considerably lower than the horizon. The sky was clear, excepting in the west, which, though free from clouds, was lightly shaded with vapours, of a yellow colour, inclining to red. Then the sun itself was exceedingly red, and was seemingly at least four times as large as he appears to be at mid-day. In these circumstances, he saw very distinctly the shadows of the trees, which were 30 or 40 feet from the white wall, coloured with a light green, inclining to blue. The shadow of an arbour, which was three feet from the wall, was exactly drawn upon it, and looked as if it had been newly painted with verdegriſe. This appearance lasted near five minutes; after which it grew fainter, and vanished at the same time with the light of the sun.

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Blue sha-
dows obser-
ved by him.

The next morning, at sunrise, he went to observe other shadows, upon another white wall; but instead of finding them green, as he expected, he observed that they were blue, or rather of the colour of lively indigo. The sky was serene, except a slight covering of yellowish vapours in the east; and the sun arose behind a hill, so that it was elevated above his horizon. In these circumstances, the blue shadows were only visible three minutes; after which they appeared black, and in the evening of the same day he observed the green shadows exactly as before. Six days passed without his being able to repeat his observations, on account of the clouds; but the 7th day, at sunset, the shadows were not green, but of a beautiful sky-blue. He also observed, that the sky was in a great measure free from vapours at that time; and that the sun set behind a rock, so that it disappeared before it came to his horizon. Afterwards he often observed the shadows both at sunrise and sunset; but always observed them to be blue, though with a great variety of shades of that colour. He showed this phenomenon to many of his friends, who were as much surprised at it as he himself had been; but he says that any person may see a blue shadow, if he will only hold his finger before a piece of white paper at sunrise or sunset.

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Explana-
tion of these
phenome-
na attempt-
ed by Abbé
Mazeas.

The first person who attempted to explain this phenomenon was the Abbé Mazeas, in a memoir of the society in Berlin for the year 1752. He observed, that when an opaque body was illuminated by the moon and a candle at the same time, and the two shadows were cast upon the same white wall, that which was enlightened by the candle was reddish, and that which was enlightened by the moon was blue. But, without attending to any other circumstances, he supposed the change of colour to be occasioned by the diminution of the light; but M. Melville, and M. Bouguer, both independent of one another, seem to have hit upon the true cause of this curious appearance, and which hath been already hinted at. The former of these gentlemen, in his attempts to explain the blue colour of the sky, observes, that since it is certain that no body assumes any particular colour, but because it reflects one sort of rays more abundantly

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Melville's
and Bou-
guer's ex-
planation.

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than the rest; and since it cannot be supposed that the constituent parts of pure air are gross enough to separate any colours of themselves; we must conclude with Sir Isaac Newton, that the violet and blue making rays are reflected more copiously than the rest, by the finer vapours diffused through the atmosphere, whose parts are not big enough to give them the appearance of visible opaque clouds. And he shows, that in proper circumstances, the bluish colour of the sky-light may be actually seen on bodies illuminated by it, as, he says, it is objected should always happen upon this hypothesis. For that if, on a clear cloudless day, a sheet of white paper be exposed to the sun's beams, when any opaque body is placed upon it, the shadow which is illuminated by the sky only will appear remarkably bluish compared with the rest of the paper, which receives the sun's direct rays.

M. Bouguer, who has taken the most pains with this subject, observes, that as M. Buffon mentions the shadows appearing green only twice, and that at all other times they were blue, this is the colour which they regularly have, and that the blue was changed into green by some accidental circumstance. Green, he says, is only a composition of blue and yellow, so that this accidental change may have arisen from the mixture of some yellow rays in the blue shadow; and that perhaps the wall might have had that tinge, so that the blue is the only colour for which a general reason is required. And this, he says, must be derived from the colour of pure air, which always appears blue, and which always reflects that colour upon all objects without distinction; but which is too faint to be perceived when our eyes are strongly affected by the light of the sun, reflected from other objects around us.

To confirm this hypothesis, he adds some curious observations of his own, in which this appearance is agreeably diversified. Being at the village of Boucholtz in July 1764, he observed the shadows projected on the white paper of his pocket-book, when the sky was clear. At half an hour past 6 in the evening, when the sun was about four degrees high, he observed that the shadow of his finger was of a dark grey, while he held the paper opposite to the sun; but when he inclined it almost horizontally, the paper had a bluish cast, and the shadow upon it was of a beautiful bright blue.

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Curious ob-
servations
relating to
this subject.

When his eye was placed between the sun and the paper laid horizontally, it always appeared of a bluish cast; but when he held the paper thus inclined between his eye and the sun, he could distinguish, upon every little eminence occasioned by the inequality of the surface of the paper, the principal of the prismatic colours. He also perceived them upon his nails, and upon the skin of his hand. This multitude of coloured points, red, yellow, green, and blue, almost effaced the natural colour of the objects.

At three quarters past six, the shadows began to be blue, even when the rays of the sun fell perpendicularly. The colour was the most lively when the rays fell upon it at an angle of 45 degrees; but with a less inclination of the paper, he could distinctly perceive, that the blue shadow had a border of a stronger blue on that side which looked towards the sky, and a red border on that side which was turned towards the earth. To see these borders, the body that made the shadow

Different
coloured
Shadows.

shadow was obliged to be placed very near the paper; and the nearer it was the more sensible was the red border. At the distance of three inches, the whole shadow was blue. At every observation, after having held the paper towards the sky, he turned it towards the earth, which was covered with verdure; holding it in such a manner, that the sun might shine upon it while it received the shadows of various bodies; but in this position he could never perceive the shadow to be blue or green at any inclination with respect to the sun's rays.

At seven o'clock, the sun being still about two degrees high, the shadows were of a bright blue, even when the rays fell perpendicularly upon the paper, but were the brightest when it was inclined at an angle of 45° . At this time he was surprised to observe, that a large tract of sky was not favourable to this blue colour, and that the shadow falling upon the paper placed horizontally was not coloured, or at least the blue was very faint. This singularity, he concluded, arose from the small difference between the light of that part of the paper which received the rays of the sun and that which was in the shade in this situation. In a situation precisely horizontal, the difference would vanish, and there could be no shadow. Thus too much or too little of the sun's light produced, but for different reasons, the same effect; for they both made the blue light reflected from the sky to become insensible. This gentleman never saw any green shadows, but when he made them fall on yellow paper. But he does not absolutely say, that green shadows cannot be produced in any other manner; and supposes, that if it was on the same wall that M. Buffon saw the blue shadows, seven days after having seen the green ones, the cause of it might be the mixture of yellow rays, reflected from the vapours, which he observes were of that colour.

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Blue shadows not
confined to
the mornings
and evenings.

These blue shadows, our author observes, are not confined to the times of the sun-rising and sun-setting; on the 19th of July, when the sun has the greatest force, he observed them at three o'clock in the afternoon, but the sun shone through a mist at that time.

If the sky is clear, the shadows begin to be blue; when, if they be projected horizontally, they are eight times as long as the height of the body that produces them, that is, when the centre of the sun is $7^\circ 8'$ above the horizon. This observation, he says, was made in the beginning of August.

Besides these coloured shadows, which are produced by the interception of the direct rays of the sun, our author observed others similar to them at every hour of the day, in rooms into which the light of the sun was reflected from some white body, if any part of the clear sky could be seen from the place, and all unnecessary light was excluded as much as possible. Observing these precautions, he says that the blue shadows may be seen at any hour of the day, even with the direct light of the sun; and that this colour will disappear in all those places of the shadow from which the blue sky cannot be seen.

All the observations that our author made upon the yellow or reddish borders of shadows above-mentioned, led him to conclude, that they were occasioned by the interception of the sky-light, whereby part of the

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shadow was illuminated either by the red rays reflected from the clouds, when the sun is near the horizon, or from some terrestrial bodies in the neighbourhood. This conjecture is favoured by the necessity he was under of placing any body near the paper, in order to produce this bordered shadow, as he says it is easily demonstrated, that the interception of the sky-light can only take place when the breadth of the opaque body is to its distance from the white ground on which the shadow falls, as twice the sine of half the amplitude of the sky to its cosine.

At the conclusion of his observations on these blue shadows, he gives a short account of another kind of them, which, he does not doubt, have the same origin. These he often saw early in the spring when he was reading by the light of a candle in the morning, and consequently the twilight mixed with that of his candle. In these circumstances, the shadow that was made by intercepting the light of his candle, at the distance of about six feet, was of a beautiful and clear blue, which became deeper as the opaque body which made the shadow was brought nearer to the wall, and was exceedingly deep at the distance of a few inches only. But wherever the day-light did not come, the shadows were all black without the least mixture of blue.

§ 6. *Of the Irradiations of the Sun's Light appearing through the interstices of the Clouds.*

THIS is an appearance which every one must have observed when the sky was pretty much overcast with clouds at some distance from each other. At that time several large beams of light, something like the appearance of the light of the sun admitted into a smoky room, will be seen generally with a very considerable degree of divergence, as if the radiant point was situated at no great distance above the clouds. Dr Smith observes that this appearance is one of those which serve to demonstrate that very high and remote objects in the heavens do not appear to us in their real shapes and positions, but according to their perspective projections on the apparent concavity of the sky. He acquaints us, that though these beams are generally seen diverging, as represented in fig. 11. it is not always the case. He himself, in particular, once saw them converging towards a point diametrically opposite to the sun: for, as near as he could conjecture, the point to which they converged was situated as much below the horizon as the sun was then elevated above the opposite part of it. This part is represented by the line DA , and the point below it in opposition to the sun is E ; towards which all the beams vt , vt , &c. appeared to converge.

“Observing (says our author) that the point of convergence was opposite to the sun, I began to suspect that this unusual phenomenon was but a case of the usual apparent divergence of the beams of the sun from his apparent place among the clouds, as represented in fig. 11. I say an apparent divergence; for though nothing is more common than for rays to diverge from a luminous body, yet the divergence of these beams in such large angles is not real, but apparent. Because it is impossible for the direct rays of the sun to cross one another at any point of the apparent concavity of the sky, in a greater angle than about half a degree. For

Irradiations
of the Sun's
Light, &c.

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Another
kind of
shadows.

Plate
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Converging
irradiations
observed by
Dr Smith.

Fig. 12.

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The phenomenon
explained by
him.

U u

the

Irradiations
of the Sun's
Light, &c.

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fig. 13.

Fig. 11.

Fig. 14.

the diameter of the earth being so extremely small, in comparison to the distance of the sun, as to subtend an angle at any point of his body of but 20 or 22 seconds at most; and the diameter of our visible horizon being extremely smaller than that of the earth; it is plain, that all the rays which fall upon the horizon from any given point of the sun, must be inclined to each other in the smallest angles imaginable: the greatest of them being as much smaller than that angle of 22 seconds, as the diameter of the visible horizon is smaller than that of the earth. All the rays that come to us from any given point of the sun may therefore be considered as parallel to each other; as the rays eBg from the point e , or fBb from the opposite point f ; and consequently the rays of these two pencils that come from opposite points of the sun's real diameter, and cross each other in the sun's apparent place B among the clouds, can constitute no greater an angle with each other than about half a degree; this angle of their intersection eBf being the same as the sun would appear under to an eye placed among the clouds at B , or (which is much the same) to an eye at O upon the ground. Because the sun's real distance OS is inconceivably greater than his apparent distance OB . Therefore the rays of the sun, as Bg , Bb , do really diverge from his apparent place B in no greater angles gBb than about half a degree. Nevertheless they appear to diverge from the place B in all possible angles, and even in opposite directions. Let us proceed then to an explanation of this apparent divergence, which is not self-evident by any means; though at first sight we are apt to think it is, by not distinguishing the vast difference between the true and apparent distances of the sun.

"What I am going to demonstrate is this. Supposing all the rays of the sun to fall accurately parallel to each other upon the visible horizon, as they do very nearly, yet in both cases they must appear to diverge in all possible angles. Let us imagine the heavens to be partly overcast with a spacious bed of broken clouds, v, v, v , &c. lying parallel to the plane of the visible horizon, here represented by the line AOD ; and when the sun's rays fall upon these clouds in the parallel lines $s v, s v$, &c. let some of them pass through their intervals in the lines $v t, v t$, &c. and fall upon the plane of the horizon at the places t, t , &c. And since the rest of the incident rays $s v, s v$, are supposed to be intercepted from the place of the spectator at O by the cloud x , and from the intervals between the transmitted rays $v t, v t$, &c. by the clouds v, v , &c. a small part of these latter rays $v t, v t$, when reflected every way from some certain kind of thin vapours floating in the air, may undoubtedly be sufficient to affect the eye with an appearance of lights and shades, in the form of bright beams in the places $v t, v t$, &c. and of dark ones in the intervals between them; just as the like beams of light and shade appear in a room by reflections of the sun's rays from a smoky or dusty air within it; the lights and shades being here occasioned by the transmission of the rays through some parts of the window, and by their interruption at other parts.

"Now, if the apparent concavity of this bed of clouds v, v , to the eye at O , be represented by the arch $ABCD$, and be cut in the point B by the line OBx drawn parallel to the beams $s v$; it will be evident by

the rules of perspective, that these long beams will not appear in their real places, but upon the concave AB Irradiations
of the Sun's
Light, &c. CD diverging every way from the place B , where the sun himself appears, or the cloud x that covers his body, as represented separately in full view in fig. 11.

"And for the same reason, if the line BO be produced towards E , below the plane of the horizon AOD , and the eye be directed towards the region of the sky directly above E , the lower ends of the same real beams $v t, v t$, will now appear upon the part DE of this concave; and will seem to converge towards the point E , situated just as much below the horizon as the opposite point B is above it: which is separately represented in full view in fig. 12.

"For if the beams $v t, v t$, be supposed to be visible throughout their whole lengths, and the eye be directed in a plane perpendicular to them, here represented by the line OF ; they and their intervals will appear broadest in and about this plane, because these parts of them are the nearest to the eye; and therefore their remoter parts and intervals will appear gradually narrower towards the opposite ends of the line BE . As a farther illustration of this matter, we may conceive the spectator at O to be situated upon the top of so large a descent OHI towards a remote valley IK , and the sun to be so very low, that the point E , opposite to him, may be seen above the horizon of this shady valley. In this case it is manifest, that the spectators at O would now see these beams converging so far as to meet each other at the point E in the sky itself.

"I do not remember to have ever seen any phenomenon of this kind by moon-light; not so much as of beams diverging from her apparent place. Probably her light is too weak after reflections from any kind of vapours, to cause a sensible appearance of lights and shades so as to form these beams. And in the unusual phenomenon I well remember, that the converging sun-beams towards the point below the horizon were not quite so bright and strong as those usually are that diverge from him; and that the sky beyond them appeared very black (several showers having passed that way), which certainly contributed to the evidence of this appearance. Hence it is probable that the thinness and weakness of the reflected rays from the vapours opposite to the sun, is the chief cause that this appearance is so very uncommon in comparison to that of diverging beams. For as the region of the sky round about the sun is always brighter than the opposite one, so the light of the diverging beams ought also to be brighter than that of the converging ones. For, though rays are reflected from rough unpolished bodies in all possible directions, yet it is a general observation, that more of them are reflected forwards obliquely, than are reflected more directly backwards. Besides, in the present case, the incident rays upon the opposite region to the sun, are more diminished by continual reflections from a longer tract of the atmosphere, than the incident rays upon the region next the sun.

"The common phenomenon of diverging beams, I think, is more frequent in summer than in winter, and also when the sun is lower than when higher up; probably because the lower vapours are denser, and therefore more strongly reflective than the higher; because the lower sky-light is not so bright as the upper; The phenomenon of
diverging
beams more
frequent in
summer
than in
winter.

Fig. 1.

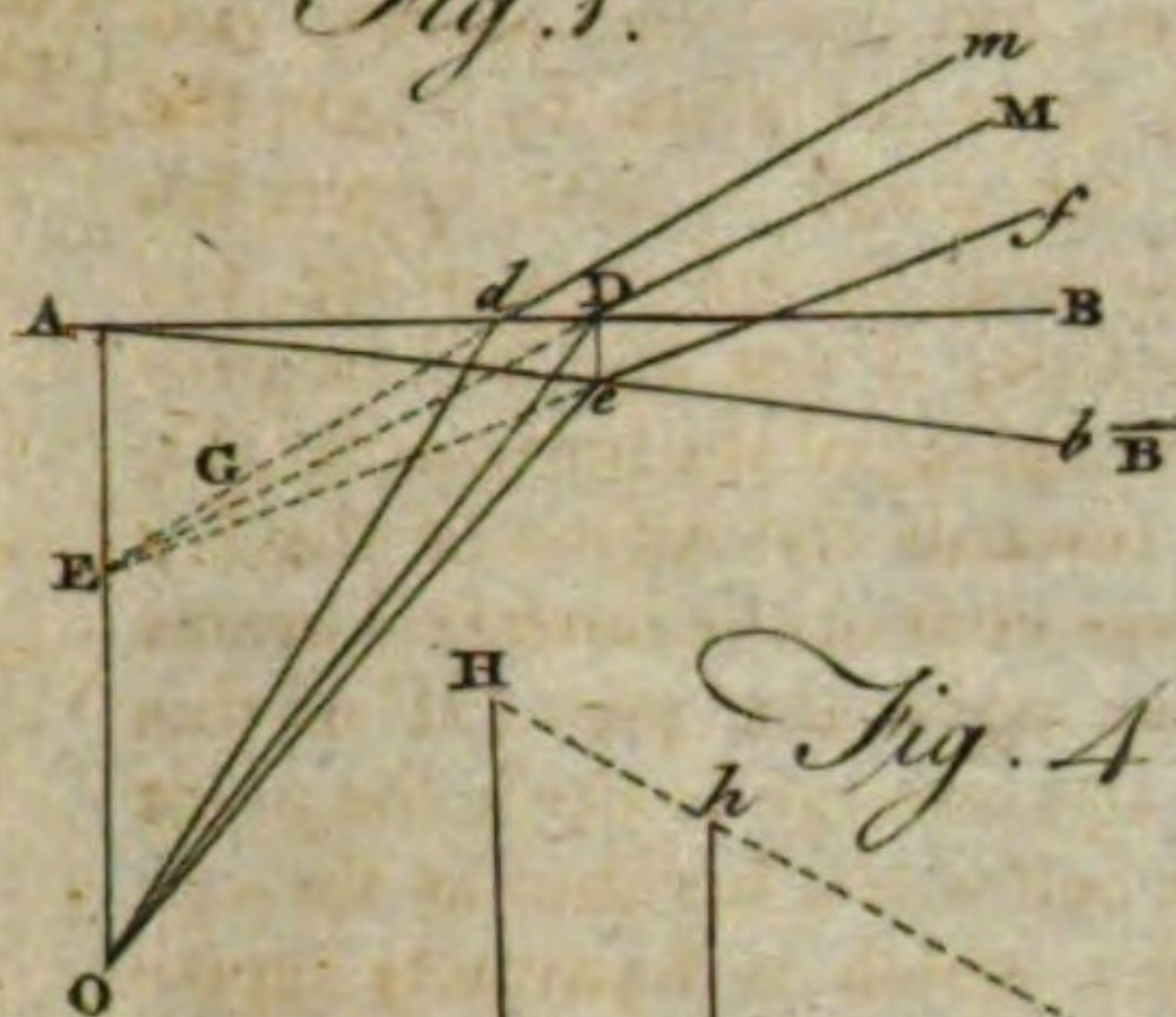


Fig. 2.



Fig. 3.

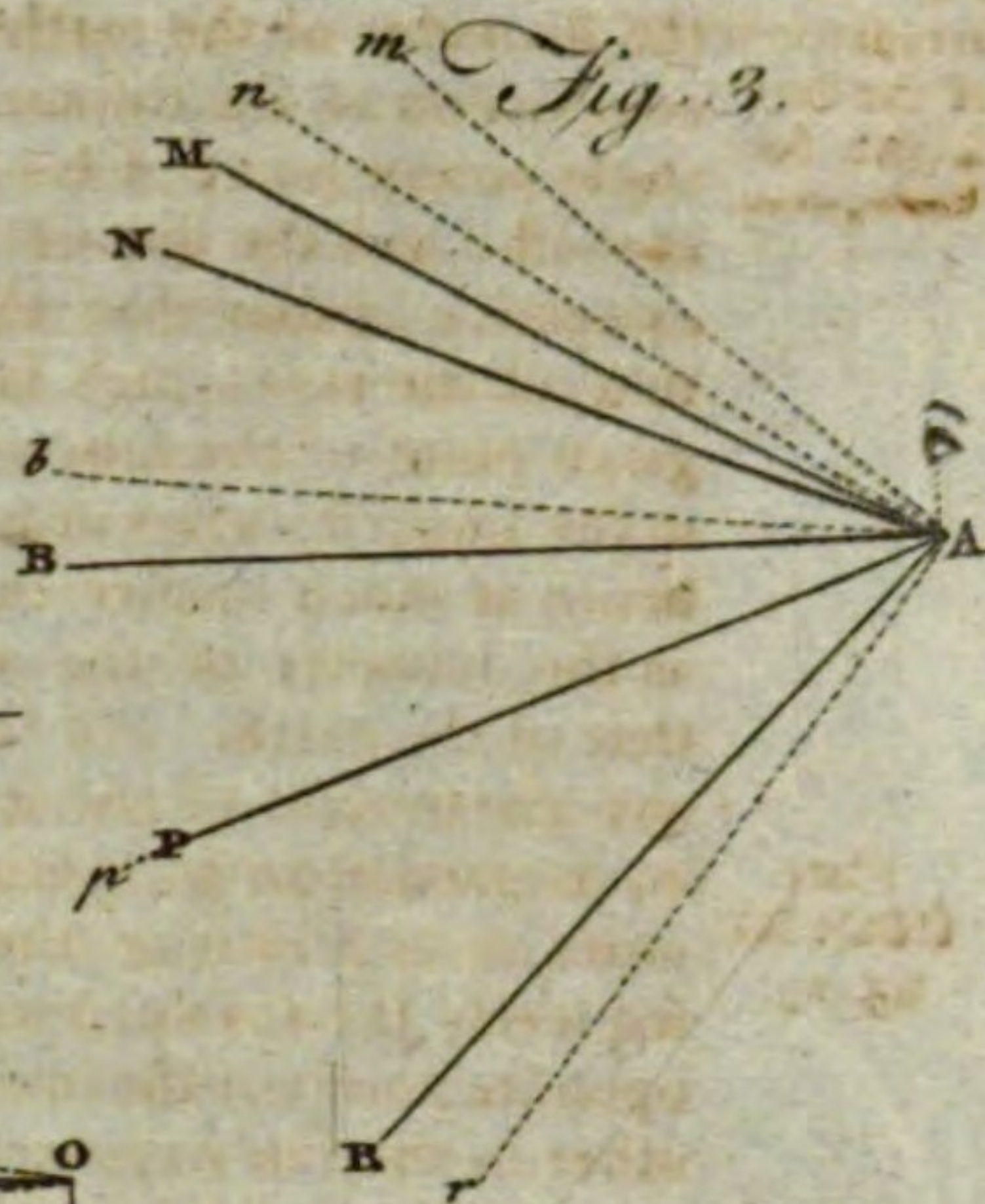


Fig. 5.

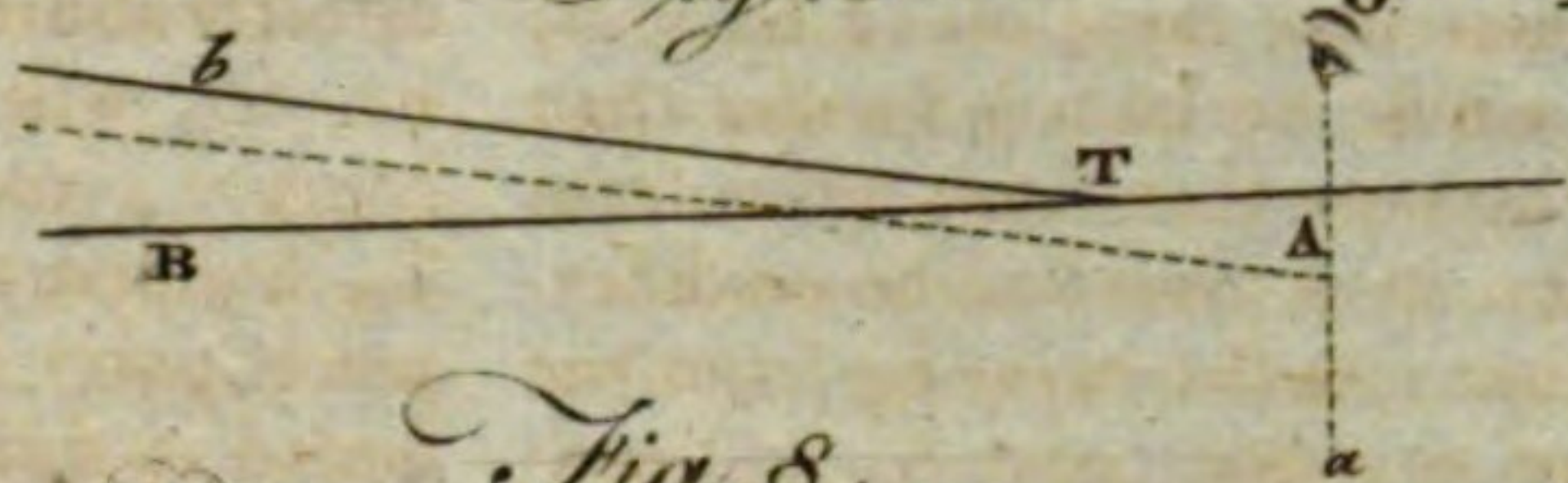


Fig. 8.

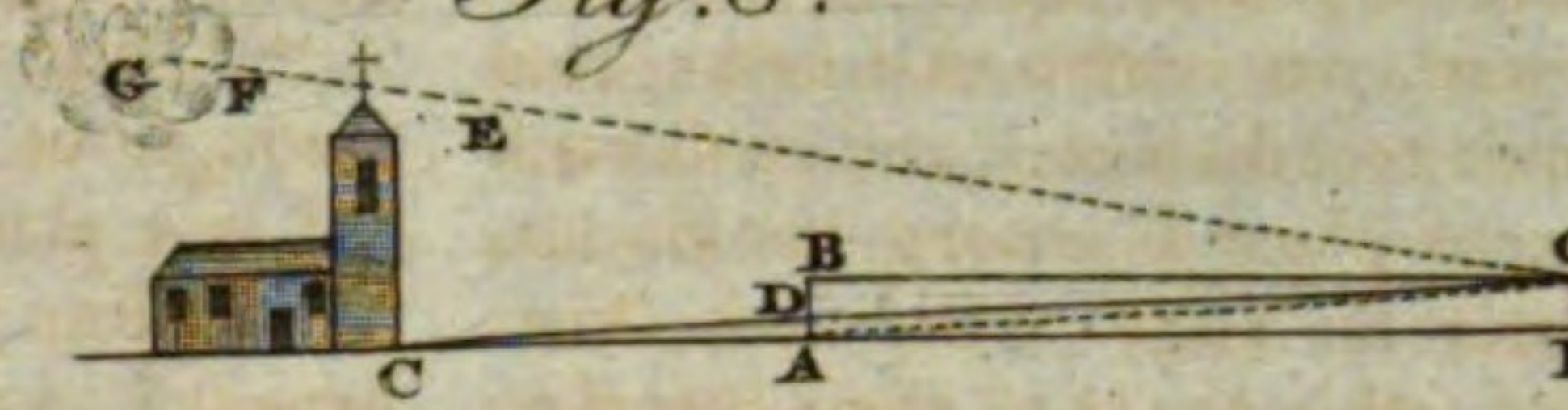


Fig. 6.

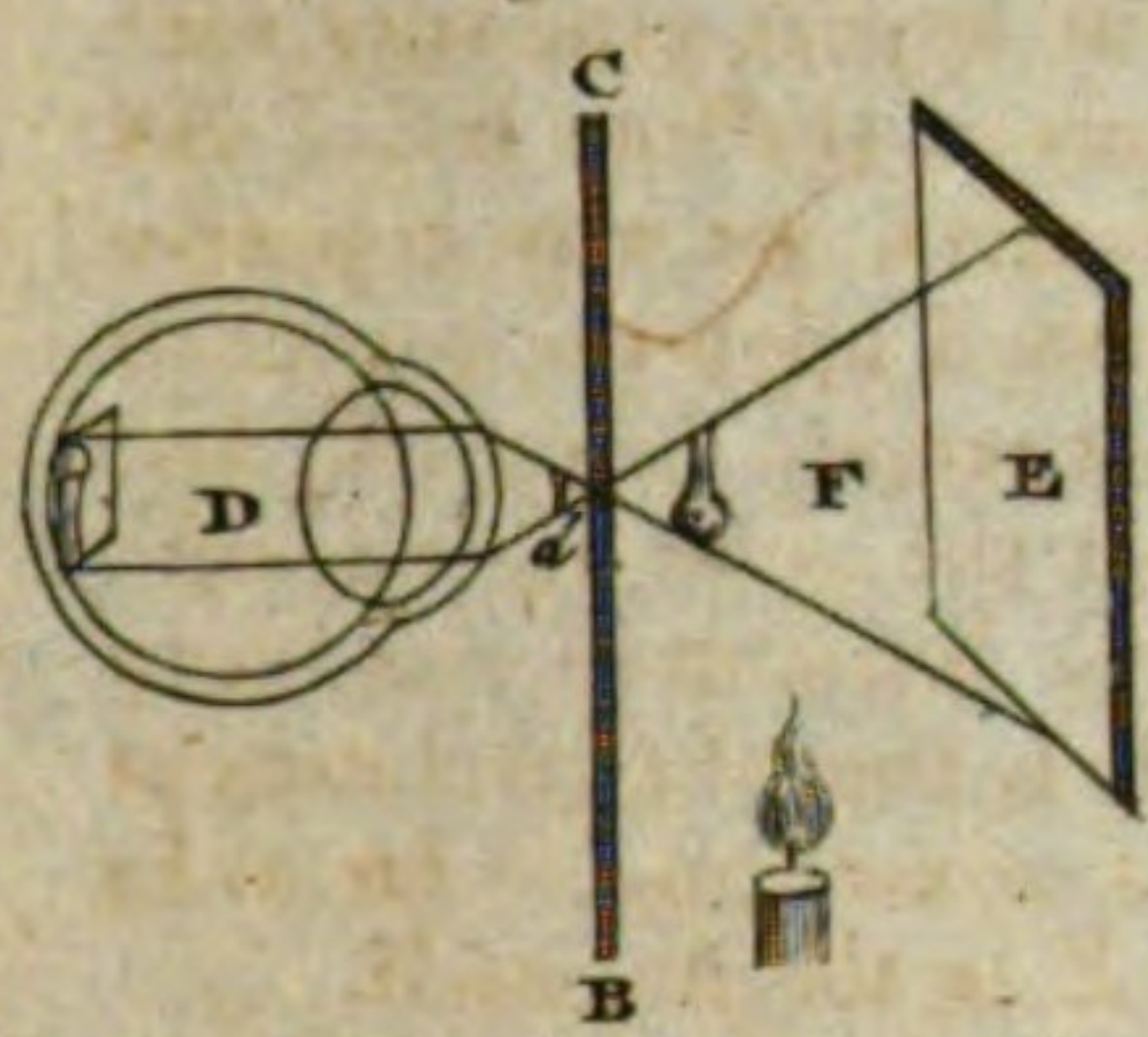


Fig. 7.

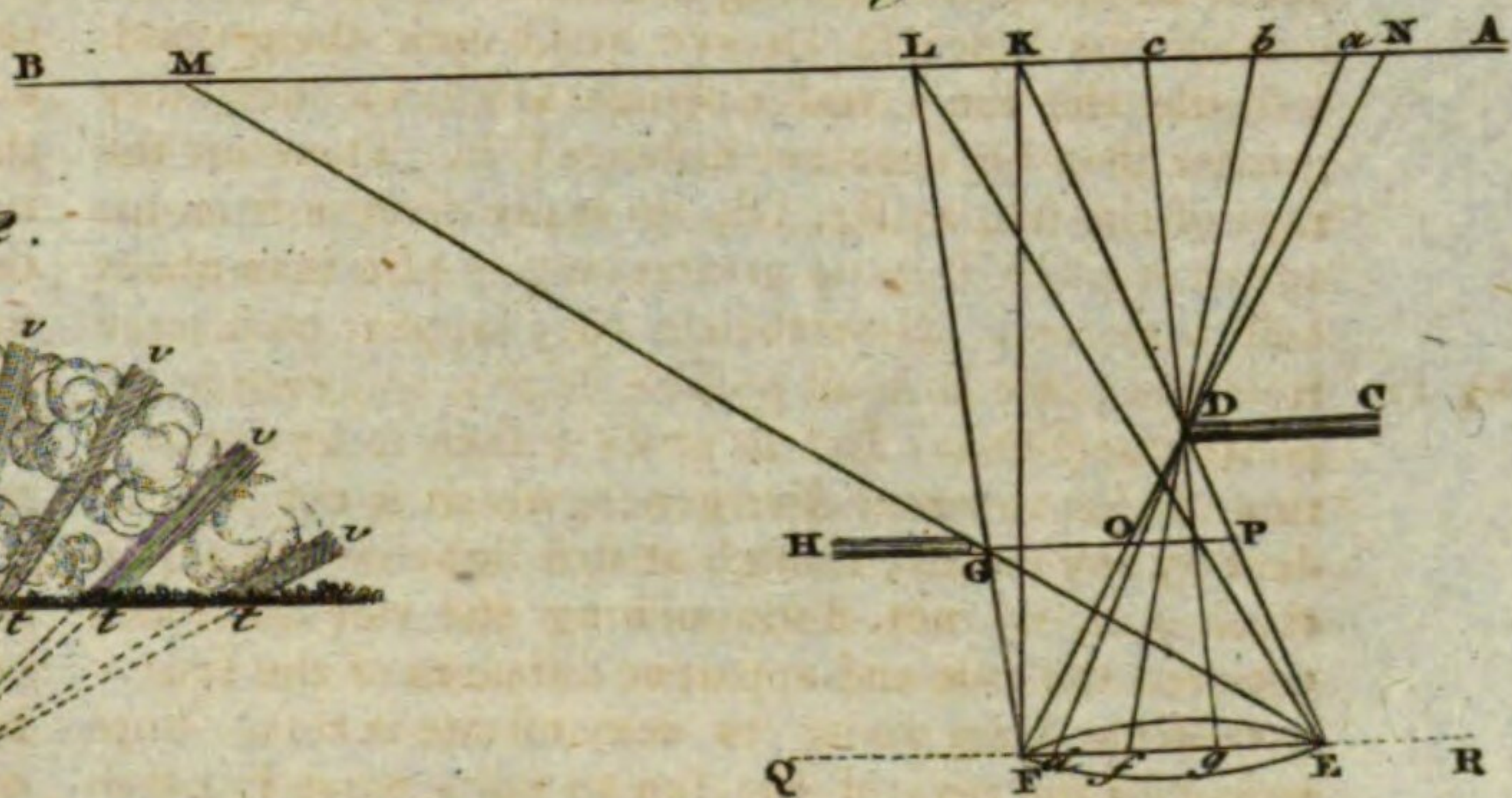


Fig. 12.

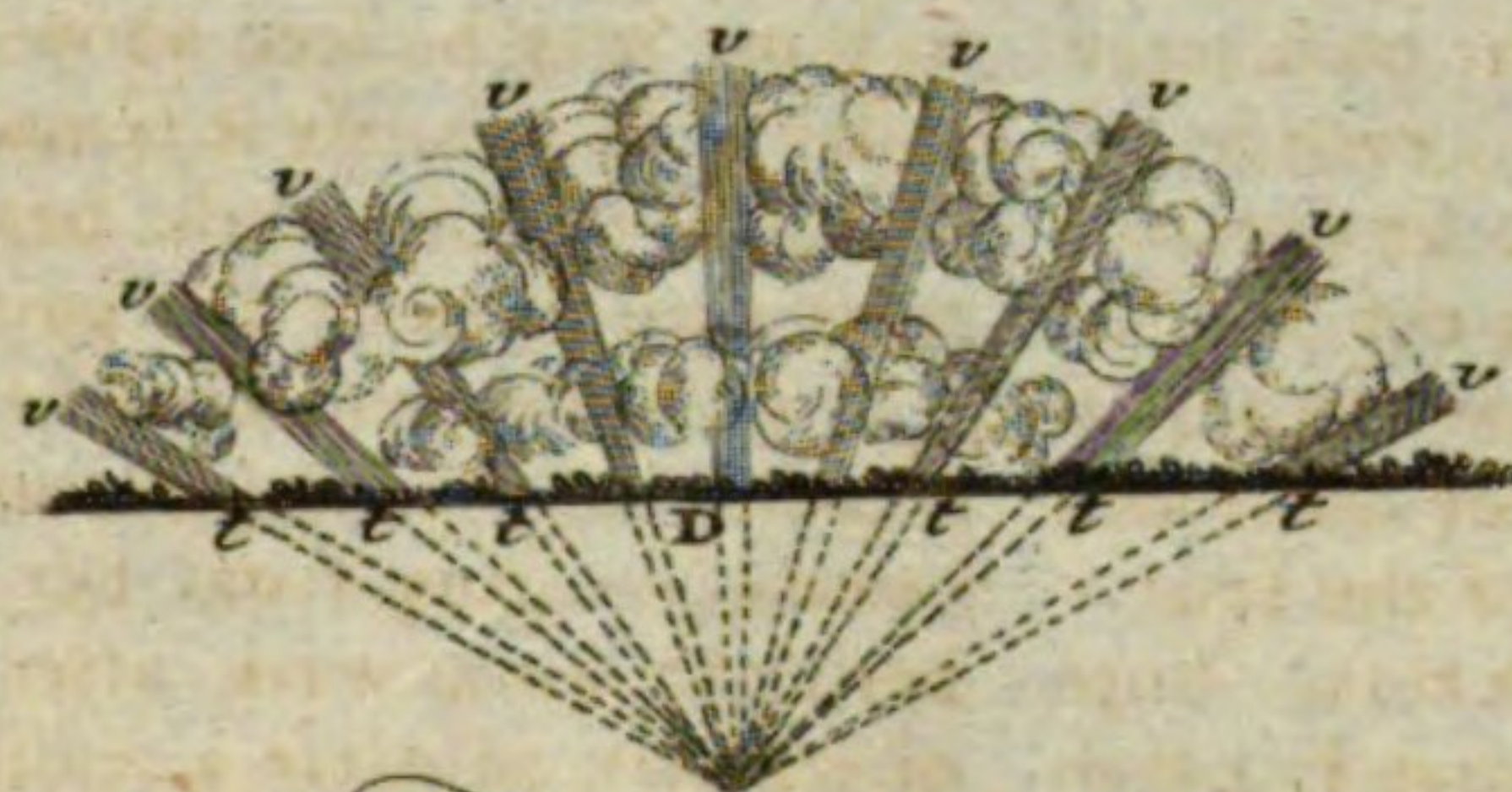


Fig. 11.



Fig. 9.

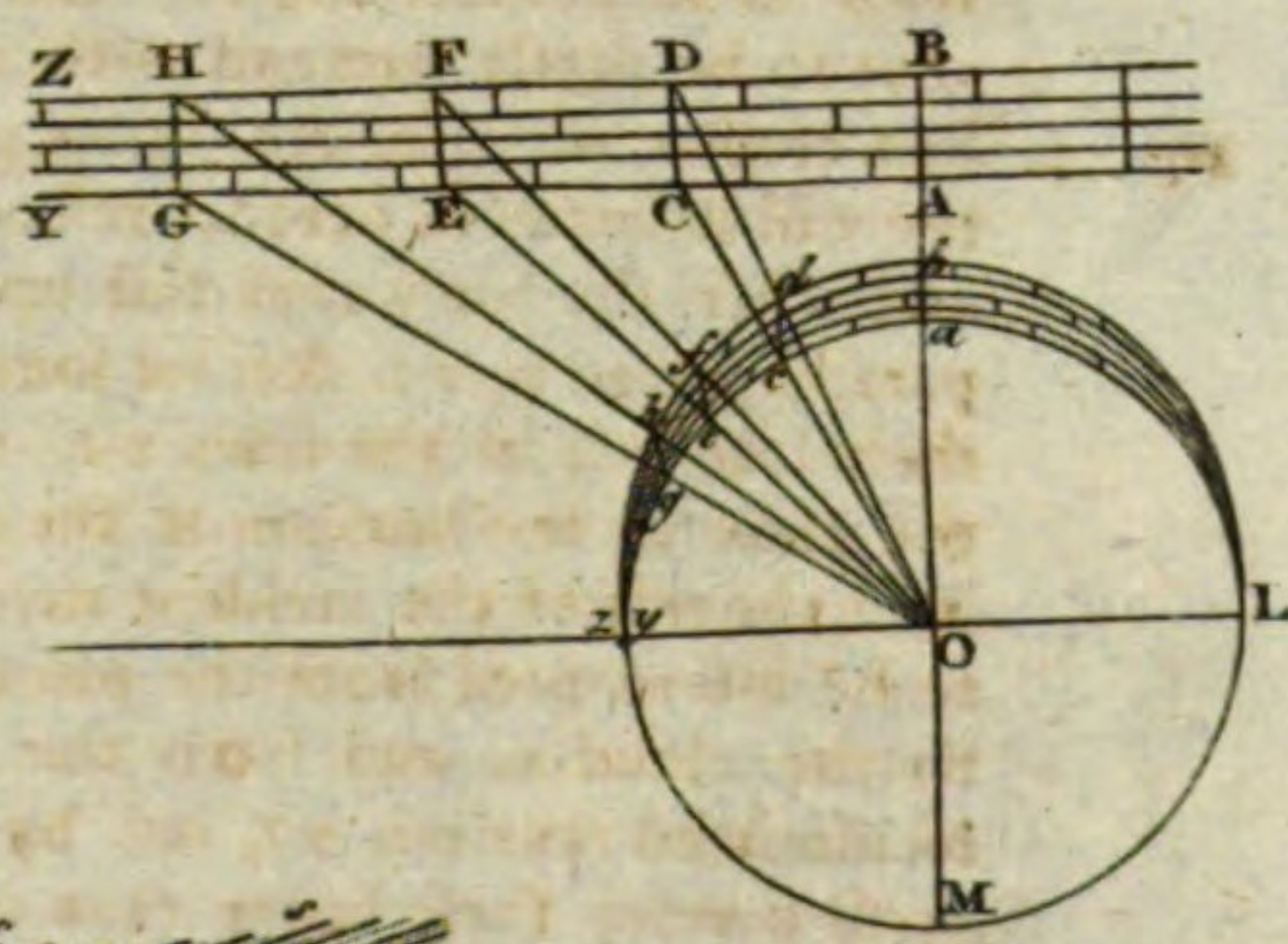


Fig. 10.

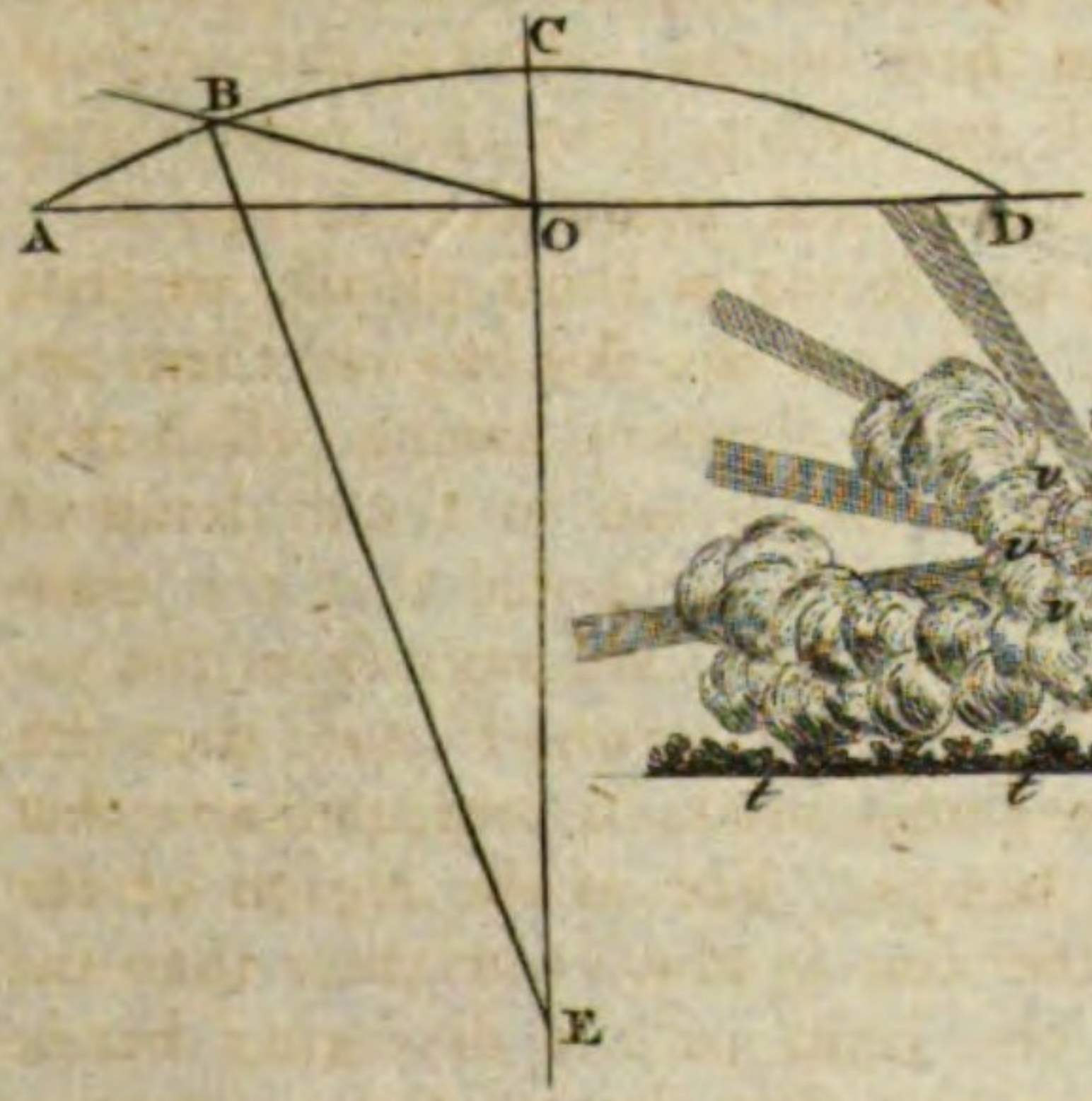


Fig. 14.

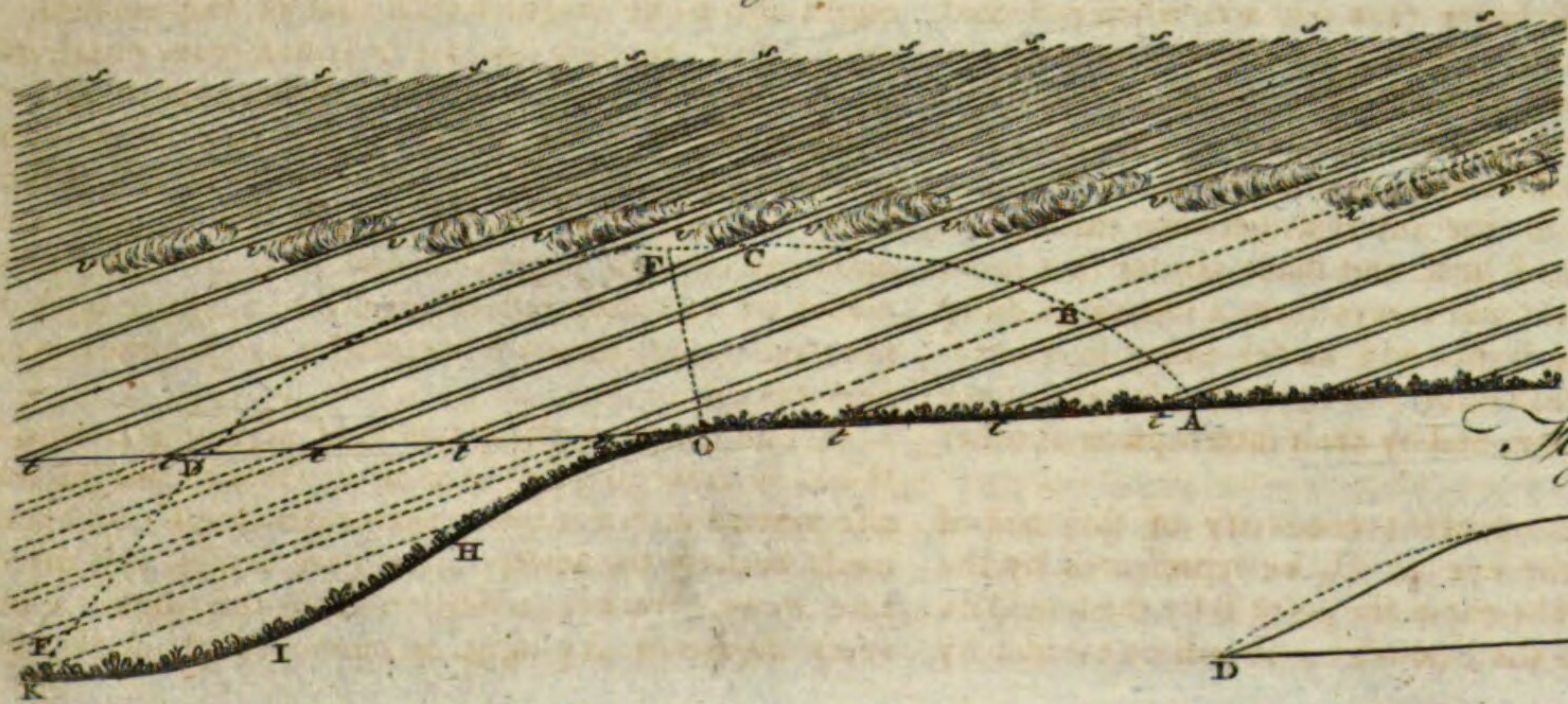
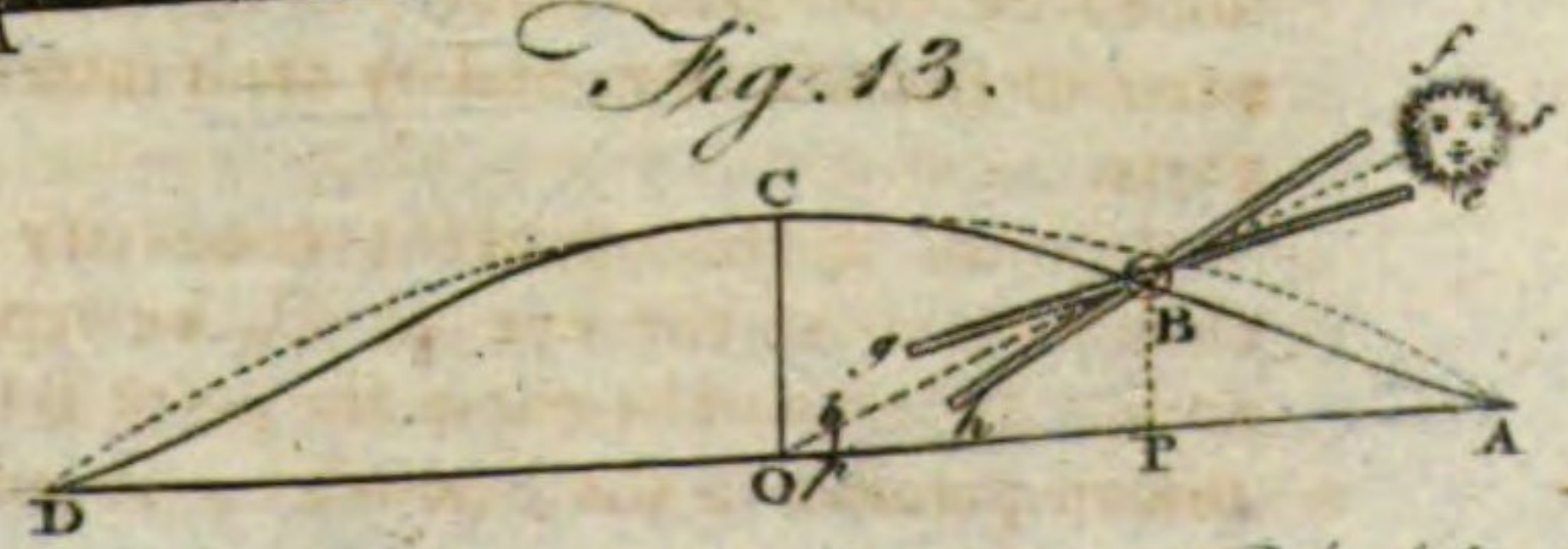


Fig. 13.



Illumina-
tion of the
Shadow of
the Earth.

per; because the air is generally quieter in the mornings and evenings than about noon-day; and lastly, because many sorts of vapours are exhaled in greater plenty in summer than in winter, from many kinds of volatile vegetables; which vapours, when the air is cooled and condensed in the mornings and evenings, may become dense enough to reflect a sensible light."

§ 7. *Of the Illumination of the Shadow of the Earth by the refraction of the Atmosphere.*

THE ancient philosophers, who knew nothing of the refractive power of the atmosphere, were very much perplexed to account for the body of the moon being visible when totally eclipsed. At such times she generally appears of a dull red colour, like tarnished copper, or of iron almost red-hot. This, they thought, was the moon's native light, by which she became visible when hid from the brighter light of the sun. Plutarch indeed, in his discourse upon the face of the moon, attributes this appearance to the light of the fixed stars reflected to us by the moon; but this must be by far too weak to produce that effect. The true cause of it is the scattered beams of the sun bent into the earth's shadow by refractions through the atmosphere in the following manner.

"Let the body of the sun, says Dr Smith, be represented by the greater circle ab , and that of the earth by the lesser one cd ; and let the lines ace and bde touch them both on their opposite sides, and meet in e beyond the earth; then the angular space ced will represent the conic figure of the earth's shadow, which would be totally deprived of the sun's rays, were none of them bent into it by the refractive power of the atmosphere. Let this power just vanish at the circle bi , concentric to the earth, so that the rays ab and bi , which touch its opposite sides, may proceed unrefracted, and meet each other at k . Then the two nearest rays to these that flow within them, from the same points a and b , being refracted inwards through the margin of the at-

mosphere, will cross each other at a point l , somewhat nearer to the earth than k ; and in like manner, two opposite rays next within the two last will cross each other at a point m , somewhat nearer to the earth than l , having suffered greater refractions, by passing through longer and denser tracts of air lying somewhat nearer to the earth. The like approach of the successive intersections k, l, m , is to be understood of innumerable couples of rays, till you come to the intersection n of the two innermost; which we may suppose just to touch the earth at the points o and p . It is plain then, that the space bounded by these rays on, np , will be the only part of the earth's shadow wholly deprived of the sun's rays. Let smg represent part of the moon's orbit when it is nearest to the earth, at a time when the earth's dark shadow onp is the longest: in this case I will show that the ratio of tm to tn is about 4 to 3; and consequently that the moon, though centrally eclipsed at m , may yet be visible by means of those scattered rays above-mentioned, first transmitted to the moon by refraction through the atmosphere, and from thence reflected to the earth.

"For let the incident and emergent parts aq, rn , of the ray $aqorn$, that just touches the earth at o , be produced till they meet at u , and let agu produced meet the axis st produced in x ; and joining us and um , since the refractions of an horizontal ray passing from o to r , or from o to q , would be alike and equal, the external angle nux is double the quantity of the usual refraction of an horizontal ray; and the angle aus is the apparent measure of the sun's semidiameter seen from the earth; and the angle ust is that of the earth's semidiameter tu seen from the sun (called his *horizontal parallax*); and lastly, the angle umt is that of the earth's semidiameter seen from the moon (called her *horizontal parallax*); because the elevation of the point u above the earth is too small to make a sensible error in the quantity of these angles; whose measures by astronomical tables are as follow:

Fig. 2.

The sun's least apparent semidiameter	= ang. aus = 15—50
The sun's horizontal parallax	= ang. ust = 00—10
Their difference * is	= ang. txu = 15—40
Double the horizontal refraction	= ang. nux = 67—30
Their sum † is	= ang. tnu = 83—10
The moon's greatest horizontal parallax	= ang. tmu = 62—10

Therefore (by a preceding prop.) we have $tm : tn ::$ (ang. $tnu : \text{ang. } tmu :: 83^\circ 10' : 62^\circ 10' ::) 4 : 3$ in round numbers; which was to be proved. It is easy to collect from the moon's greatest horizontal parallax of $62^\circ 10'$, that her least distance tm is about $55\frac{1}{2}$ semidiameters of the earth; and therefore the greatest length tn of the dark shadow, being three quarters of tm , is about $41\frac{1}{2}$ semidiameters.

"The difference of the last mentioned angles tnu, tmu , is $mun = 21'$, that is, about two thirds of $31' - 40'$, the angle which the whole diameter of the sun subtends at u . Whence it follows, that the middle point m of the moon centrally eclipsed, is illuminated by rays which come from two thirds of every diameter of the sun's disk, and pass by one side of the earth; and also by rays that come from the opposite

two thirds of every one of the said diameters, and pass by the other side of the earth. This will appear by conceiving the ray $aqorn$ to be inflexible, and its middle point o to slide upon the earth, while the part rn is approaching to touch the point m ; for then the opposite part qa will trace over two thirds of the sun's diameter. The true proportion of the angles num, aus , could not be preserved in the scheme, by reason of the sun's immense distance and magnitude with respect to the earth.

"Having drawn the line ata , it is observable, that all the incident rays, as aq, ar , flowing from any one point of the sun to the circumference of the earth, will be collected to a focus a , whose distance ta is less than tm in the ratio of 62 to 67 nearly; and thus an image of the sun will be formed at $a\beta$, whose rays

Fig. 3.

U u 2

will

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Why the
moon is vi-
sible when
totally
eclipsed.

Plate
CCCLXII.
fig. 1.

* Eucl. I.
prop. 32.

† Ibid.

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of Light.

will diverge upon the moon. For the angle τau is the difference of the angles xua , uat found above; and τa : tm : : ang. tmu : ang. τau : : $62' - 10''$: $67 - 30'$.

"The rays that flow next above aq and a' , by passing through a thinner part of the atmosphere, will be united at a point in the axis ata somewhat farther from the earth than the last focus a ; and the same may be said of the rays that pass next above these, and so on; whereby an infinite series of images of the sun will be formed, whose diameters and degrees of brightness will increase with their distances from the earth.

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Why the
moon ap-
pears duller
when eclipsed
in her
perigee
than in her
apogee.

"Hence it is manifest why the moon eclipsed in her perigee is observed to appear always duller and darker than in her apogee. The reason why her colour is always of the copper kind between a dull red and orange, I take to be this. The blue colour of a clear sky shows manifestly that the blue-making rays are more copiously reflected from pure air than those of any other colour; consequently they are less copiously transmitted through it among the rest that come from the sun, and so much the less as the tract of air through which they pass is the longer. Hence the common colour of the sun and moon is whitest in the meridian, and grows gradually more inclined to diluted yellow, orange, and red, as they descend lower, that is, as the rays are transmitted through a longer tract of air; which tract being still lengthened in passing to the moon and back again, causes a still greater loss of the blue-making rays in proportion to the rest; and so the resulting colour of the transmitted rays must lie between a dark orange and red, according to Sir Isaac Newton's rule for finding the result of a mixture of colours. We have an instance of the reverse of this case in leaf-gold, which appears yellow by reflected and blue by transmitted rays. The circular edge of the shadow in a partial eclipse appears red; because the red-making rays are the least refracted of all others, and consequently are left alone in the conical surface of the shadow, all the rest being refracted into it.

§ 8. Of the Measures of Light.

THAT some luminous bodies give a stronger, and others a weaker light, and that some reflect more light than others, was always obvious to mankind; but no person, before M. Bouguer, hit upon a tolerable method of ascertaining the proportion that two or more lights bear to one another. The methods he most commonly used were the following.

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M. Bou-
guer's con-
trivances
for measur-
ing light.
Plate
CCCLXII.

He took two pieces of wood or pasteboard EC and CD (fig. 4.), in which he made two equal holes P and Q , over which he drew pieces of oiled or white paper. Upon these holes he contrived that the light of the different bodies he was comparing should fall; while he placed a third piece of pasteboard FC , so as to prevent the two lights from mixing with one another. Then placing himself sometimes on one side, and sometimes on the other, but generally on the opposite side of this instrument, with respect to the light, he altered their position till the papers in the two holes appeared to be equally enlightened. This being done, he computed the proportion of their light by the squares of the distances at which the luminous bodies were placed from the objects. If, for instance, the

distances were as three and nine, he concluded that the light they gave were as nine and eighty-one. Where any light was very faint, he sometimes made use of lenses, in order to condense it; and he inclosed them in tubes or not as his particular application of them required.

To measure the intensity of light proceeding from the heavenly bodies, or reflected from any part of the sky, he contrived an instrument which resembles a kind of portable camera obscura. He had two tubes, of which the inner was black, fastened at their lower extremities by a hinge C , (fig. 5.) At the bottom of these tubes were two holes, R and S , three or four lines in diameter, covered with two pieces of fine white paper. The two other extremities had each of them a circular aperture, an inch in diameter; and one of the tubes consisted of two, one of them sliding into the other, which produced the same effect as varying the aperture at the end. When this instrument is used, the observer has his head, and the end of the instrument C , so covered, that no light can fall upon his eye, besides that which comes through the two holes S and R , while an assistant manages the instrument, and draws out or shortens the tube DE , as the observer directs. When the two holes appear equally illuminated, the intensity of the lights is judged to be inversely as the squares of the tubes.

In using this instrument, it is necessary that the object should subtend an angle larger than the aperture A or D , seen from the other end of the tube; for, otherwise, the lengthening of the tube has no effect. To avoid, in this case, making the instrument of an inconvenient length, or making the aperture D too narrow, he has recourse to another expedient. He constructs an instrument, represented (fig. 6.), consisting of two object-glasses, AE and DF , exactly equal, fixed in the ends of two tubes six or seven feet, or, in some cases, 10 or 12 feet long, and having their foci at the other ends. At the bottom of these tubes B , are two holes, three or four lines in diameter, covered with a piece of white paper; and this instrument is used exactly like the former.

If the two objects to be observed by this instrument be not equally luminous, the light that issues from them must be reduced to an equality, by diminishing the aperture of one of the object-glasses; and then the remaining surface of the two glasses will give the proportion of their lights. But for this purpose, the central parts of the glass must be covered in the same proportion with the parts near the circumference, leaving the aperture such as is represented (fig. 7.), because the middle part of the glass is thicker and less transparent than the rest.

If all the objects to be observed lie nearly in the same direction, our author observes, that these two long tubes may be reduced into one, the two object-glasses being placed close together, and one eye-glass sufficing for them both. The instrument will then be the same with that of which he published an account in 1748, and which he called a *beliometer*, or *astrometer*.

Our author observes, that it is not the absolute quantity, but only the intensity of the light, that is measured by these two instruments, or the number of rays, in proportion to the surface of the luminous body; and it is of great importance that these two things

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of Light.

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These in-
struments
measure on-
ly the in-
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be

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of Light.Measures
of Light.

be distinguished. The intensity of light may be very great, when the quantity, and its power of illuminating other bodies, may be very small, on account of the smallness of its surface; or the contrary may be the case, when the surface is large.

Having explained these methods which M. Bouguer took to measure the different proportions of light, we shall subjoin in this place a few miscellaneous examples of his application of them.

It is observable, that when a person stands in a place where there is a strong light, he cannot distinguish objects that are placed in the shade; nor can he see any thing upon going immediately into a place where there is very little light. It is plain, therefore, that the action of a strong light upon the eye, and also the impression which it leaves upon it, makes it insensible to the effect of a weaker light. M. Bouguer had the curiosity to endeavour to ascertain the proportion between the intensities of the two lights in this case; and by throwing the light of two equal candles upon a board, he found that the shadow made by intercepting the light of one of them, could not be perceived by his eye, upon the place enlightened by the other, at little more than eight times the distance; from whence he concluded, that when one light is eight times eight, or 64 times less than another, its presence or absence will not be perceived. He allows, however, that the effect may be different on different eyes; and supposes that the boundaries in this case, with respect to different persons, may lie between 60 and 80.

Applying the two tubes of his instrument, mentioned above, to measure the intensity of the light reflected from different parts of the sky; he found, that when the sun was 25 degrees high, the light was four times stronger at the distance of eight or nine degrees from his body, than it was at 31 or 32 degrees. But what struck him the most was to find, that when the sun is 15 or 20 degrees high, the light decreases on the same parallel to the horizon to 110 or 120 degrees, and then increases again to the place exactly opposite to the sun.

The light of the sun, our author observes, is too strong, and that of the stars too weak, to determine the variation of their light at different altitudes: but as, in both cases, it must be in the same proportion with the diminution of the light of the moon in the same circumstances, he made his observations on that luminary, and found, that its light at $19^{\circ} 16'$, is to its light at $66^{\circ} 11'$, as 1681 to 2500; that is, the one is nearly two thirds of the other. He chose those particular altitudes, because they are those of the sun at the two solstices at Croisic, where he then resided. When one limb of the moon touched the horizon of the sea, its light was 2000 times less than at the altitude of $66^{\circ} 11'$. But this proportion he acknowledges must be subject to many variations, the atmosphere near the earth varying so much in its density. From this observation he concludes, that at a medium light is diminished in the proportion of about 2500 to 1681, in traversing 7469 toises of dense air.

Lastly, our accurate philosopher applied his instrument to the different parts of the sun's disk, and found that the centre is considerably more luminous than the extremities of it. As near as he could make the ob-

servation, it was more luminous than a part of the disk $\frac{1}{4}$ ths of the semidiameter from it, in the proportion of 35 to 28; which, as he observes, is more than in the proportion of the sines of the angles of obliquity. On the other hand, he observes, that both the primary and secondary planets are more luminous at their edges than near their centres.

The comparison of the light of the sun and moon is a subject that has frequently exercised the thoughts of philosophers; but we find nothing but random conjectures, before our author applied his accurate measures in this case. In general, the light of the moon is imagined to bear a much greater proportion to that of the sun than it really does; and not only are the imaginations of the vulgar, but those of philosophers also, imposed upon with respect to it. It was a great surprise to M. de la Hire to find that he could not, by the help of any burning mirror, collect the beams of the moon in a sufficient quantity to produce the least sensible heat. Other philosophers have since made the like attempts with mirrors of greater power, though without any greater success; but this will not surprise us, when we see the result of M. Bouguer's observations on this subject.

In order to solve this curious problem concerning the comparison of the light of the sun and moon, he compared each of them to that of a candle in a dark room, one in the day-time, and the other in the night following, when the moon was at her mean distance from the earth; and, after many trials, he concluded that the light of the sun is about 300,000 times greater than that of the moon; which is such a disproportion, that, as he observes, it can be no wonder that philosophers have had so little success in their attempts to collect the light of the moon with burning-glasses. For the largest of them will not increase the light 1000 times; which will still leave the light of the moon, in the focus of the mirror, 300 times less than the intensity of the common light of the sun.

To this account of the proportion of light which we actually receive from the moon, it cannot be displeasing to the reader, if we compare it with the quantity which would have been transmitted to us from that opaque body, if it reflected all the light it receives. Dr Smith thought that he had proved, from two different considerations, that the light of the full moon would be to our day-light as 1 to about 90,900, if no rays were lost at the moon.

In the first place, he supposes that the moon, enlightened by the sun, is as luminous as the clouds are at a medium. He therefore supposed the light of the sun to be equal to that of a whole hemisphere of clouds, or as many moons as would cover the surface of the heavens. But on this Dr Priestley observes, that it is true, the light of the sun shining perpendicularly upon any surface would be equal to the light reflected from the whole hemisphere, if every part reflected all the light that fell upon it; but the light that would in fact be received from the whole hemisphere (part of it being received obliquely) would be only one-half as much as would be received from the whole hemisphere, if every part of it shone directly upon the surface to be illuminated.

In his Remarks, par. 97, Dr Smith demonstrates his method of calculation in the following manner.

“ Let

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Great variation of the light of the moon at different altitudes.

247
Variation in different parts of the disks of the sun and planets.

248
M. Bouguer's calculation concerning the light of the moon.

249
Dr Smith's calculation.

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fig. 8.

“ Let the little circle $cf dg$ represent the moon's body half enlightened by the sun, and the great circle aeb , a spherical shell concentric to the moon, and touching the earth; ab , any diameter of that shell perpendicular to a great circle of the moon's body, represented by its diameter cd ; e the place of the shell receiving full moon light from the bright hemisphere fdg . Now, because the surface of the moon is rough like that of the earth, we may allow that the sun's rays, incident upon any small part of it, with any obliquity, are reflected from it every way alike, as if they were emitted. And therefore, if the segment df shone alone, the points a, e , would be equally illuminated by it; and likewise if the remaining bright segment dg shone alone, the points b, e would be equally illuminated by it. Consequently, if the light at the point a was increased by the light at b , it would become equal to the full moon-light at e . And conceiving the same transfer to be made from every point of the hemispherical surface $bbik$ to their opposite points in the hemisphere $kaeb$, the former hemisphere would be left quite dark, and the latter would be uniformly illuminated with full moon-light; arising from a quantity of the sun's light, which, immediately before its incidence on the moon, would uniformly illuminate a circular plane equal to a great circle of her body, called her *disk*. Therefore the quantities of light being the same upon both surfaces, the density of the sun's incident light is to the density of full moon-light, as that hemispherical surface bek is to the said disk; that is, as any other hemispherical surface whose centre is at the eye, to that part of it which the moon's disk appears to possess very nearly, because it subtends but a small angle at the eye: that is, as radius of the hemisphere to the versed sine of the moon's apparent semidiameter, or as 10,000,000 to $1106\frac{2}{3}$ or as 90,400 to 1; taking the moon's mean horizontal diameter to be $16' 7''$.

“ Strictly speaking, this rule compares moon-light at the earth with day-light at the moon; the medium of which, at her quadratures, is the same as our day-light; but is less at her full in the duplicate ratio of 365 to 366, or thereabout, that is, of the sun's distances from the earth and full moon: and therefore full-moon light would be to our day-light as about 1 to 90,900, if no rays were lost at the moon.

“ Secondly, I say that full-moon light is to any other moon light as the whole disk of the moon to the part that appears enlightened, considered upon a plane surface. For now let the earth be at b , and let dl be perpendicular to fg , and gm to cd ; then it is plain, that gl is equal to dm ; and that gl is equal to a perpendicular section of the sun's rays incident upon the arch dg , which at b appears equal to dm ; the eye being unable to distinguish the unequal distances of its parts. In like manner, conceiving the moon's surface to consist of innumerable physical circles parallel to $cf dg$, as represented at A , the same reason holds for every one of these circles as for $cf dg$. It follows then, that the bright part of the surface visible at b , when reduced to a flat as represented at B , by the crescent $pdqmp$, will be equal and similar to a perpendicular section of all the rays incident on that

part, represented at C by the crescent pgq/p . Now the whole disk being in proportion to this crescent, as the quantities of light incident upon them; and the light falling upon every rough particle, being equally rarified in diverging to the eye at b , considered as equidistant from them all; it follows, that full moon-light is to this moon-light as the whole disk $pdqc$ to the crescent $pdqmp$.

“ Therefore, by compounding this ratio with that in the former remark, day-light is to moon-light as the surface of an hemisphere whose centre is at the eye, to the part of that surface which appears to be possessed by the enlightened part of the moon.”

Mr Michell made his computation in a much more simple and easy manner, and in which there is much less danger of falling into any mistake. Considering the distance of the moon from the sun, and that the density of the light must decrease in the proportion of the square of that distance, he calculated the density of the sun's light, at that distance, in proportion to its density at the surface of the sun; and in this manner he found, that if the moon reflected all the light it receives from the sun, it would only be the 45,000th part of the light we receive from the greater luminary. Admitting, therefore, that moon-light is only a 300,000th part of the light of the sun, Mr Michell concludes, that it reflects no more than between the 6th and 7th part of what falls upon it.

SECT. IV. Of Aberration.

THE great practical use of the science of optics is to aid human sight; but it has been repeatedly observed during the progress of this article, that in constructing dioptrical instruments for this purpose, great difficulties arise from the aberration of light. It has been shown, page 288, &c. how to determine the concurrence of any refracted ray PF' with the ray $RVCF'$ (figs. 5, 6, &c. Plate CCCLV.) which passes through the centre C , and therefore falls perpendicularly on the spherical surface at the vertex V , and suffers no refraction. This is the conjugate focus to R for the two rays RP, RV , and for another ray flowing from R and falling on the surface at an equal distance on the opposite side to P . In short, it is the conjugate focus for all the rays flowing from R and falling on the spherical surface in the circumference of a circle described by the revolution of the point P round the axis $RVCF'$; that is, of all the rays which occupy the conical surface described by the revolution of RP , and the refracted rays occupy the conical surface produced by the revolution of PF' .

But no other rays flowing from R are collected at F' ; for it appeared in the demonstration of that proposition, that rays incident at a greater distance from the axis RC were collected at a point between C and F' ; and then the rays which are incident on the whole arch PC , or the spherical surface generated by its revolution round RC , although they all cross the axis RC , are diffused over a certain portion of it, by what has been called the aberration of figure. It is called also (but improperly) the aberration from the geometrical focus, by which is meant the focus of an infinitely slender pencil of rays, of which the middle ray (or axis of the pencil) occupies the lens RC , and

Fig. 1.

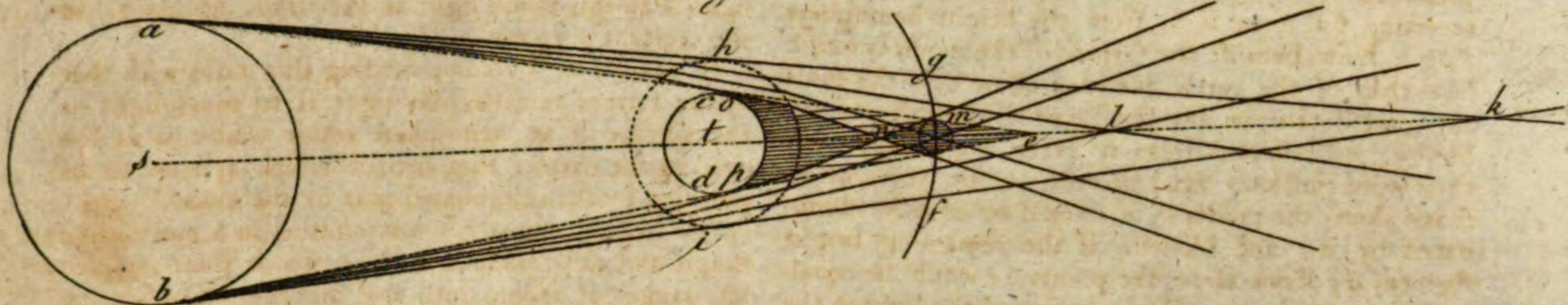


Fig. 2.

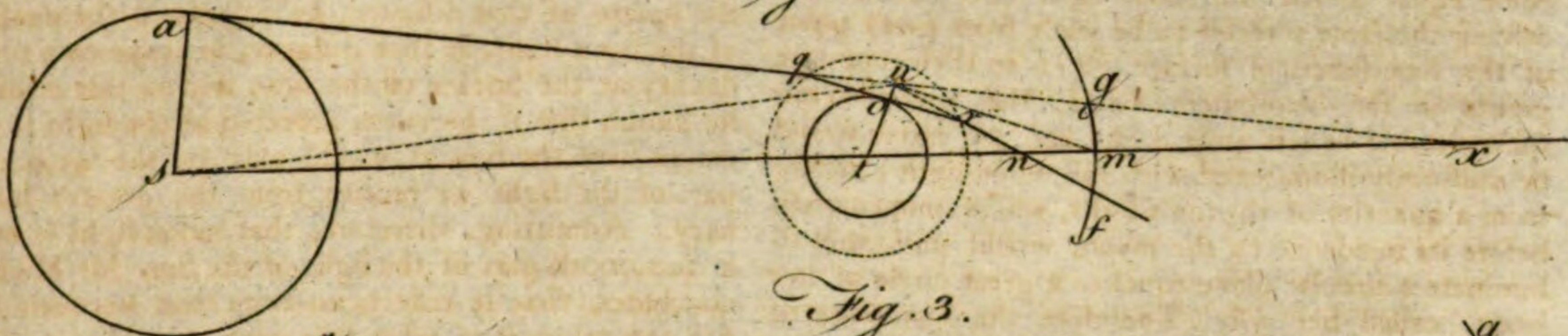


Fig. 3.

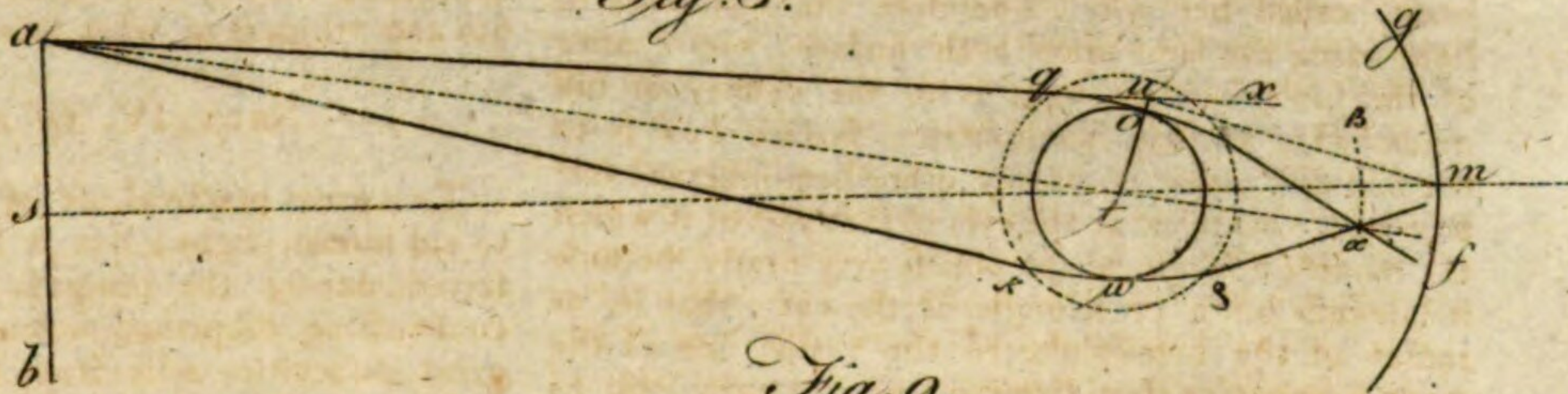


Fig. 4.

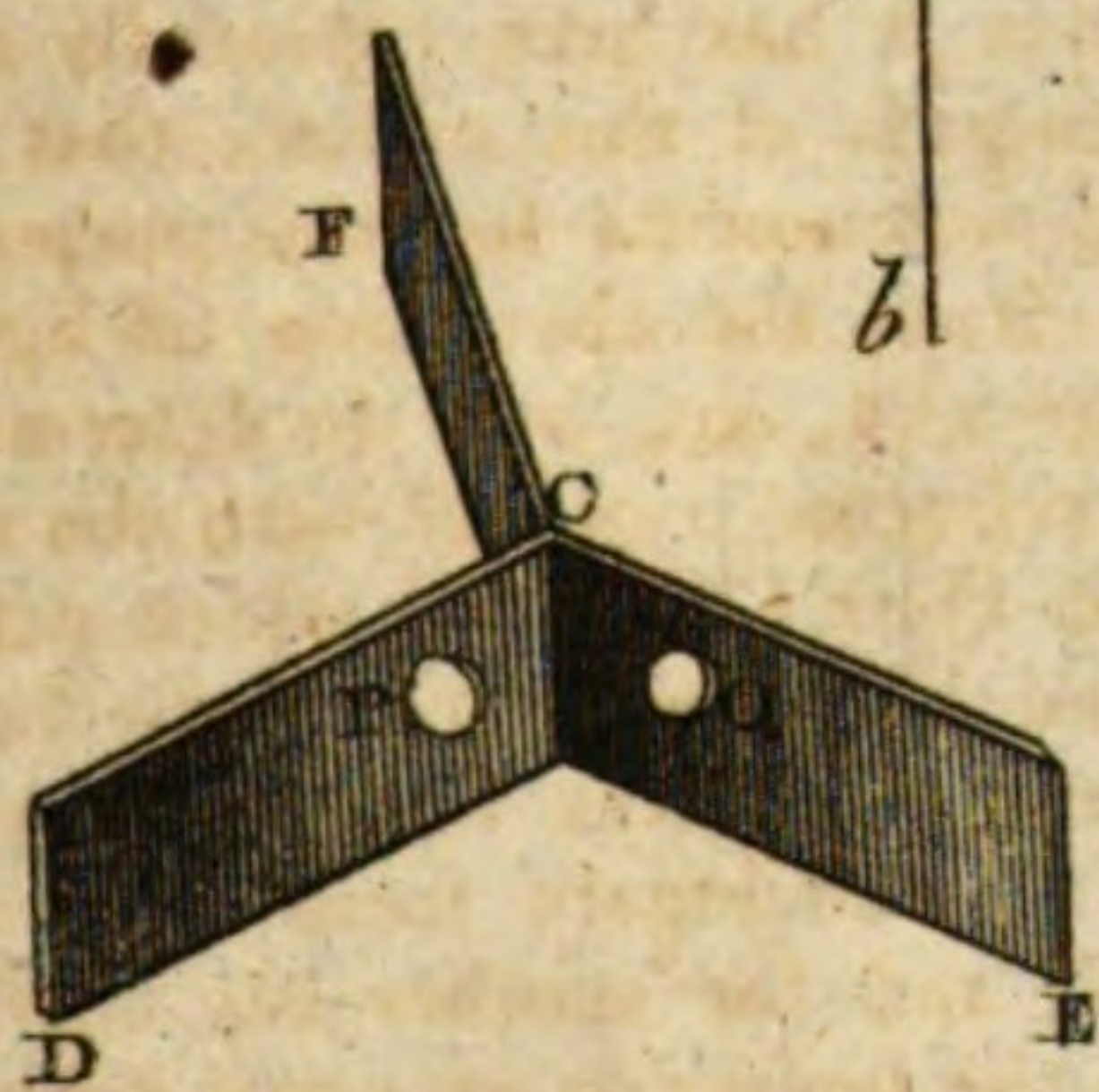


Fig. 9.

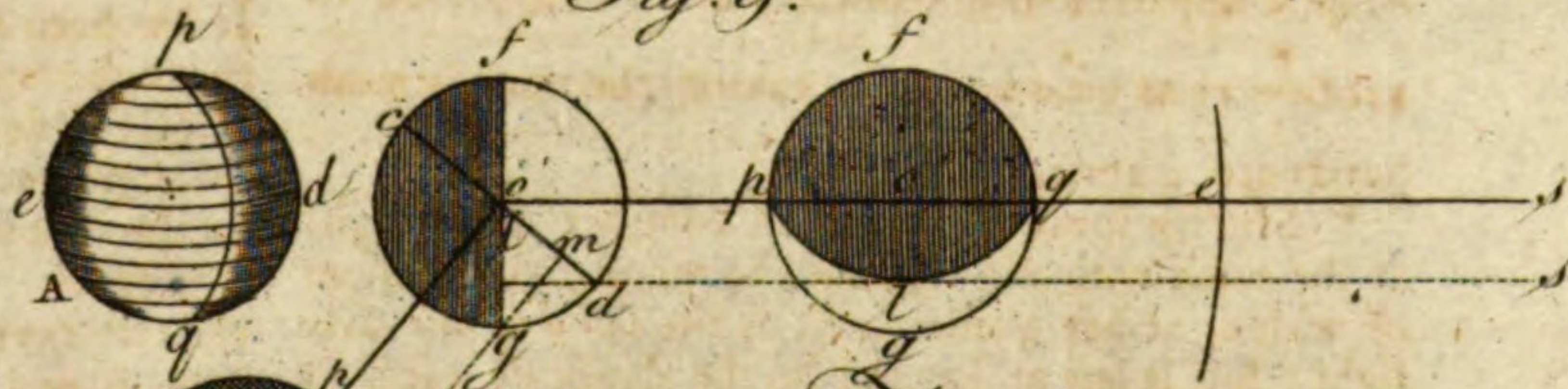


Fig. 6.

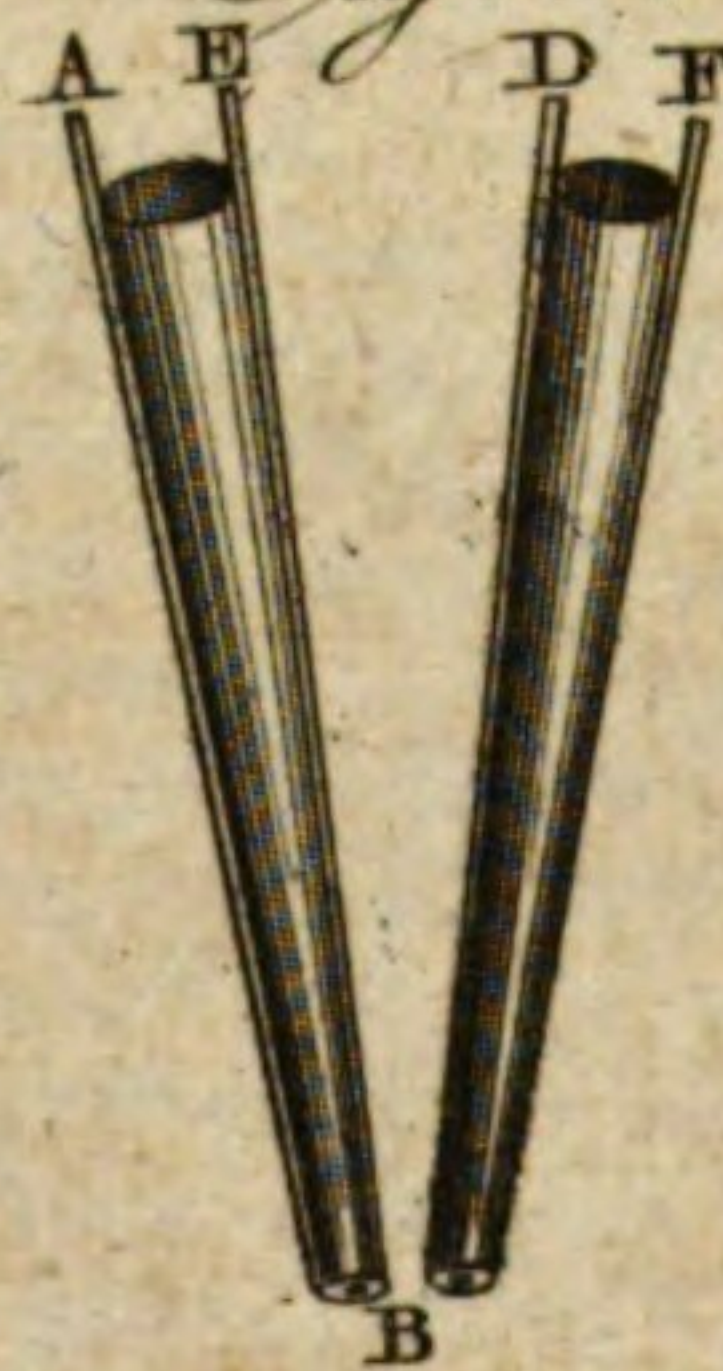


Fig. 5.

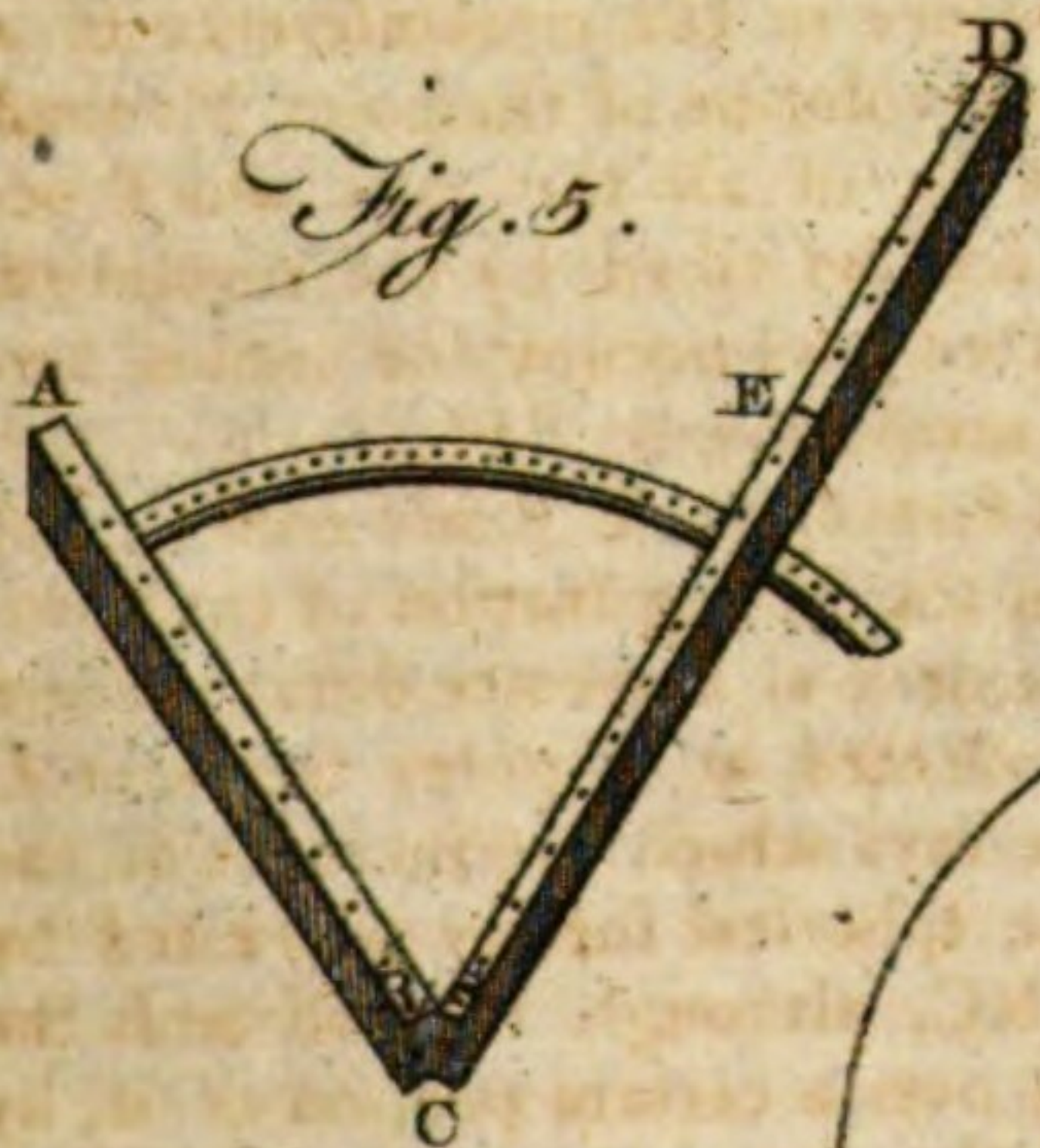


Fig. 8.

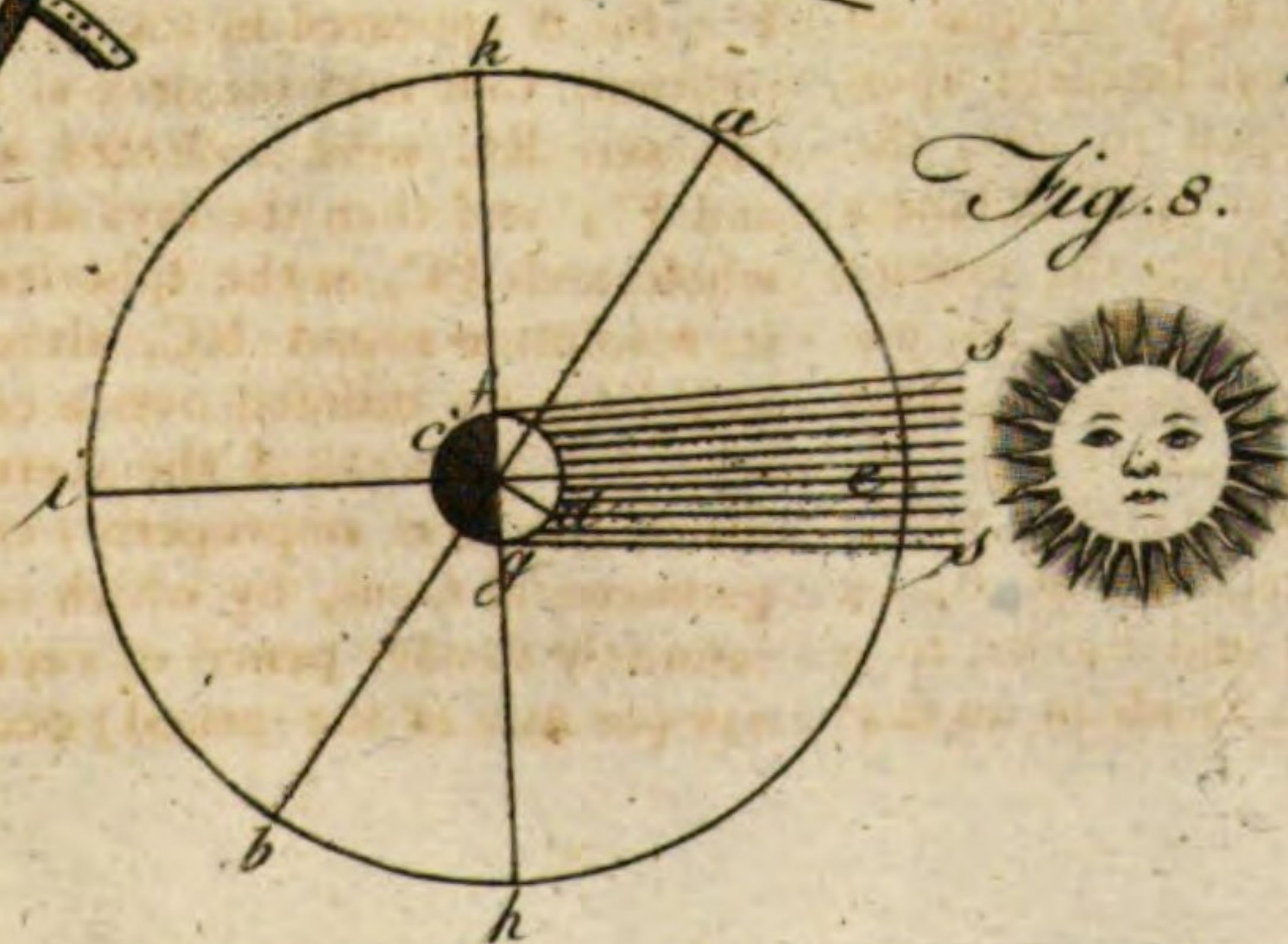


Fig. 7.



Of Aberra-
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suffers no refraction. But there is no such focus. But if we make $mRV = nRC : mRV = VC : VF$, the point F is called the geometrical focus, and is the remotest limit from C of all the foci (equally geometrical) of rays flowing from R. The other limit is easily determined by constructing the problem for the extreme point of the given arch.

It is evident from the construction, that while the point of incidence P is near to V, the line CK increases but very little, and therefore CF diminishes little, and the refracted rays are but little diffused from F; and therefore they are much denser in its vicinity than any other point of the axis. It will soon be evident that they are incomparably denser. It is on this account that the point F has been called the conjugate focus *κατ' ἑσώχην*, to R, and the geometrical focus and the diffusion has been called *aberration*. A geometrical point R is thus represented by a very small circle (or physical point as it is improperly called) at F, and F has drawn the chief attention. And as, in the performance of optical instruments, it is necessary that this extended representation of a mathematical point R be very small, that may not sensibly interfere with the representations of the points adjacent to R, and thus cause indistinct vision, a limit is thus set to the extent of the refracting surface which must be employed to produce this representation. But this evidently diminishes the quantity of light, and renders the vision *obscure*, though distinct. Artists have therefore endeavoured to execute refracting surfaces of forms not spherical, which collect accurately to one point the light issuing from another, and the mathematicians have furnished them with forms having this property; but their attempts have been fruitless. Spherical surfaces are the only ones which can be executed with accuracy. All are done by grinding the refracting substance in a mould of proper materials. When this is spherical, the two work themselves, with moderate attention, into an exact sphere; because if any part is more prominent than another, it is ground away, and the whole gets of necessity one curvature. And it is astonishing to what degree of accuracy this is done. An error of the millionth part of an inch would totally destroy the figure of a mirror of an inch focal distance, so as to make it useless for the coarsest instrument. Therefore all attempts to make other figures are given up. Indeed other reasons make them worse than spherical, even when accurately executed. They would not collect to accurate focuses the rays of oblique pencils.

It is evident from these observations, that the theory of aberrations is absolutely necessary for the successful construction of optical instruments; and it must be acceptable to the reader to have a short account of it in this place. Enough shall be said here to show the general nature and effects of it in optical instruments, and in some of the more curious phenomena of nature. Under the article TELESCOPE the subject will be resumed, in such a manner as to enable the reader who possesses a very moderate share of mathematical knowledge, not only to understand how aberrations are increased and diminished, but also how, by a proper employment of contrary aberrations, their hurtful effects may be *almost entirely* removed in all important cases. And the manner in which the sub-

ject shall be treated in the present general sketch, will have the advantage of pointing out at the same time the maxims of construction of the greatest part of optical instruments, which generally produce their effects by means of pencils of rays which are either out of the axis altogether, or are oblique to it; cases which are seldom considered in elementary treatises of optics.

Let PV (fig. 1.) be a spherical surface of a refracting substance (glass for instance), of which C is the centre, and let an indefinitely slender pencil of rays AP be incident on it, in a direction parallel to a ray CV passing through the centre. It is required to determine the focus f of this pencil.

Let AP be refracted into PF . Draw CI , CR the sines of incidence and refraction, and CP the radius. Draw RB perpendicular to CP , and Bf parallel to AP or CV . I say, first, f is the focus of the indefinitely slender pencil, or, more accurately speaking, f is the remotest limit from P of the concourse of rays with PF , refracted by points lying without the arch VP , or the nearest limit for rays incident between V and P.

Draw the radius Cp , the line pf ; and draw pg parallel to Pf , and PO perpendicular to Pf . It is evident, that if f be the focus, $c'pf$ is the angle of refraction corresponding to the angle of incidence apC , as $C'Pf$ is the angle corresponding to APC . Also PCp is the increment of the angle of incidence, and the angle $c'pg$ is equal to the sum of the angle $C'Pf$ and $C'Cc$, and the angle gpf is equal to the angle pfp . Therefore $c'pf = C'Pf + P'Cc + Pfp$. Therefore $PCp + Pfp$ is the corresponding increment of the angle of refraction. Also, because $RPo = CPp$ (being right angles) the angle $pPo = RPC$, and $Po : Pp = PR : PC$.

Therefore, by a preceding Lemma in this article, Page 286, we have $PCp + Pfp : PCp = \tan. \text{ref.} : \tan. \text{incid.} = \&c.$

$T, R : T, I$; and $Pfp : PCp = T, R - T, I : T, I$,
 $= \text{diff.} : T, I$; but $Pfp : PCp = \frac{Po}{Pp} : \frac{PR}{PC} = \frac{PR}{Pp} : \frac{PR}{PC}$,
 $= PR : Pp = DR : DB$ (because DP is parallel to Bf by construction) $= \tan. CPR - \tan. CPI : \tan. CPI$. Now CPI is the angle of incidence; and therefore CPR is the angle properly corresponding to it as an angle of refraction, and the point f is properly determined.

Hence the following rule: As the difference of the tangents of incidence and refraction is to the tangent of incidence, so is the radius of the surface multiplied by the cosine of refraction to the distance of the focus of an indefinitely slender pencil of parallel incident rays.

N. B. We here consider the cosine of refraction as a number. This was first done by the celebrated Leonhard Euler, and is one of the greatest improvements in mathematics which this century can boast of. The sines, tangents, secants, &c. are considered as fractional numbers, of which the radius is unity. Thus, $CP \times$

$\sin. 30^\circ$, is the same thing with $\frac{1}{2} CP$, or $\frac{CP}{2}$. And in like manner, CB , drawn perpendicular to the axis $\times$

$\sin. 19^\circ 28' 16'' 32'''$, is the same thing with $\frac{1}{3}$ of CB .

Also $\frac{CB}{\cos. 60^\circ}$ is the same thing with twice CB , &c.

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medy the
evils of ab-
errations.

Of Aberra-
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In this manner, $BE = BC \times \sin. BCE$, and also $BE = CE \times \tan. BCE$, and $CB = CE \times \sec. BCE$, &c. &c. This manner of considering the lines which occur in geometrical constructions is of immense use in all parts of mixed mathematics; and no where more remarkably than in optics, the most beautiful example of them. Of this an important instance shall now be given.

Corol. 1. The distance fG of this lateral focus from the axis CV (that is, from the line drawn through the centre parallel to the incident light) is proportional to the cube of the semi-aperture PH of the spherical surface.

For $fG = BE$. Now $BE = CB \times \sin. BCE$, $= CB \times \sin. CPA$; and $CB = RC \times \cos. RCB$, $= RC \times \sin. CPR$, and $RC = CP \times \sin. CPR$: Therefore $BE = PC \times \sin.^2 CPR \times \sin. PCA$, $= PC \times \sin.^2 \text{ refr.} \times \sin. \text{ incid.}$

but $\sin.^2 \text{ refr.} = \frac{m^2}{n^2} \sin.^2 \text{ incid.}$ Therefore, finally,

BE , or $fG = PC \times \frac{m^2}{n^2} \times \sin.^2 \text{ incid.}$ But $PC \cdot \sin. \text{ incid.}$

is evidently PH the semi-aperture; therefore the proposition is manifest.

Corol. 2. Now let this slender pencil of rays be incident at the vertex V . The focus will now be a point F in the axis, determined by making $CV : CF = m : n$. Let the incident pencil gradually recede from the axis CF , still, however, keeping parallel to it. The focus f will always be found in a curve line $DC'F$, so constituted that the ordinate G will be as the cube of the line PH , perpendicular to the axis intercepted between the axis and that point of the surface which is cut by a tangent to the curve in f .

All the refracted rays will be tangents to this curve, and the adjacent rays will cross each other in these lateral foci f ; and will therefore be incomparably more dense along the curve than any where within its area. This is finely illustrated by receiving on white paper the light of the sun refracted through a globe or cylinder of glass filled with water. If the paper is held parallel to the axis of the cylinder, and close to it, the illuminated part will be bounded by two very bright parallel lines, where it is cut by the curve; and these lines will gradually approach each other as the paper is withdrawn from the vessel, till they coalesce into one very bright line at F , or near it. If the paper be held with its end touching the vessel, and its plane nearly perpendicular to the axis, the whole progress at the curve will be distinctly seen.

As such globes were used for burning-glasses, the point of greatest condensation (which is very near but not exactly in F) was called the *focus*. When these curves were observed by Mr Tschirnhaus, he called them *caustics*; and those formed by refraction he called *diacaustics*, to distinguish them from the *catacaustics* formed by reflection.

It is somewhat surprising, that these curves have been so little studied since the time of Tschirnhaus. The doctrine of aberrations has indeed been considered in a manner independent on their properties. But whoever considers the progress of rays in the eye-piece of optical instruments, will see that the knowledge of the properties of diacaustic curves determines directly, and almost accurately, the foci and images that are formed there. For, let the object-glass of a telescope or microscope be of any dimensions, the pencils inci-

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dent on the eye-glasses are almost all of this evanescent bulk. These advantages will be shown in their proper places: and we proceed at present to extend our knowledge of aberrations in general, first considering the aberrations of parallel incident rays.

Abiding by the instance represented by the figure, it is evident that the caustic will touch the surface in a point φ , so situated that $c\varphi : \varphi X = m : n$. The refracted ray $\varphi\Phi$ will touch the surface, and will cross the axis in Φ , the nearest limit of diffusion along the axis. If the surface is of smaller extent, as PV , the caustic begins at f , when the extreme refracted ray Pf touches the caustic, and crosses the axis in F' , and the opposite branch of the caustic in K . If there be drawn an ordinate $KO k$ to the caustic, it is evident that the whole light incident on the surface PV passes through the circle whose diameter is Kk , and that the circle is the smallest space which receives *all* the refracted light.

It is of great importance to consider the manner in which the light is distributed over the surface of this circle of smallest diffusion; for this is the representation of one point of the infinitely distant radiant object. Each point of a planet, for instance, is represented by this little circle; and as the circles representing the different adjacent points must interfere with each other, an indistinctness must arise similar to what is observed when we view an object through a pair of spectacles which do not fit the eye. The indistinctness must be in proportion to the number of points whose circles of diffusion interfere; that is, to the area of these circles, provided that the light is uniformly diffused over them: but if it be very rare at the circumference, the impression made by the circles belonging to the adjacent points must be less sensible. Accordingly, Sir Isaac Newton, supposing it incomparably rarer at the circumference than towards the centre, affirms, that the indistinctness of telescopes arising from the spherical figure of the object-glass was some thousand times less than that arising from the unequal refrangibility of light; and therefore, that the attempts to improve them by diminishing or removing this aberration were needless, while the distinctness from unequal refrangibility remained. It is surprising, that a philosopher so eminent for sagacity and for mathematical knowledge, should have made such a mistake, and unfortunate that the authority of his great name hindered others from examining the matter, trusting to his assertion, that the light was so rare at the border of this circle. His mistake is surprising, because the very nature of a caustic should have showed him, that the light was infinitely dense at the borders of the circle of smallest diffusion. The first person who detected this oversight of the British philosopher was the Abbé Boscovich, who, in a dissertation published at Vienna in 1767, showed, by a very beautiful analysis, that the distribution was extremely different from what Newton had asserted, and that the superior indistinctness arising from unequal refrangibility was incomparably less than he had said. We shall attempt to make this delicate and interesting matter conceivable by those who have but small mathematical preparation.

Let the curve $DVZCIc\varphi d$ (fig. 2.) be the caustic (magnified), EI its axis, I the focus of central rays, B the focus of extreme rays, and IB the line containing

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ing the the foci of all the intermediate rays, and CO c the diameter of the circle of smallest diffusion.

It is plain, that from the centre O there can be drawn two rays OV, O v , touching the caustic in V, v . Therefore the point O will receive the ray EO, which passes through the vertex of the refracting surface, and all the rays which are incident on the circumference of a circle described on the refracting surface by the extremity of the ray OV, or O v . The density of the light at O will therefore be indefinitely great.

From the point C there can be drawn two rays; one of them CX touching the caustic in C, and the other C, touching it at d on the opposite side. The rays which touch the caustic in the immediate vicinity of Cy, both in the arch CV and the arch CI will cut OC in points indefinitely near to each other; because their distance from each other in the line OC will be to their uniform distance on the refracting surface as the distance between their points of contact with the caustic to the distance of these points from the refracting surface. Here therefore at C the density of the light will also be indefinitely great.

From any point H, lying between O and C, may be drawn three rays. One of them, LHT, P, touching the arch CD of the caustic in T, cutting the refracting surface in P, and the axis in L: another, tHp , touching the arch CI of the caustic in t . The third is $H\tau\pi$, touching the arch cd of the opposite branch of the caustic in τ .

It will greatly assist our conceptions of this subject, if we consider a ray of light from the refracting surface as a thread attached at I of this figure, or at F of fig. 1. and gradually unlapped from the caustic DVC I on one side, and then lapped on the opposite branch I $c v d$; and attend to the point of its intersection with the diameter c OC of the circle of smallest diffusion.

Therefore, 1. let the ray be first supposed to pass through the refracting surface at F, the right hand extremity of the aperture. The thread is then folded up on the whole right hand branch ICVD of the caustic; and if the straight part of it FD be produced, it will cut the diameter of the circle of smallest diffusion in the opposite extremity c . Or suppose a ruler in place of the thread, applied to the caustic at D and to the refracting surface at F, the part of it D c , which is detached from the caustic, cuts CO c in the point c . 2. Now suppose the ruler to revolve gradually, its extremity moving across the arch FA of the refracting surface while the edge is applied to the caustic; the point of contact with the caustic will shift gradually down the branch DV of the caustic, while its edge passes across the line c C; and when the point of contact arrives at V, the extremity will be at Y on the refracting surface, and the intersection of the edge will be at O. 3. Continuing the motion, the point of contact shifts from V to Z, the extremity from Y to Q', and the intersection from O to Q, so

that $OQ^2 = \frac{OC^2}{2}$, as will presently appear. 4. After this, the point of contact will shift from Z to C, the extremity from Q' to X, halfway from F to A, as will soon be shown, and the intersection from Q to C. 5. The point of contact will now shift from C down to I, the extremity will pass from X to A, and the intersection will go back from C to O. 6. The

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ruler must now be applied to the other branch of the caustic I $c v d$, and the point of contact will ascend from I to c , the extremity will pass from A to x , half way to f from A, and the intersection from O to c . 7. The point of contact will ascend from C to z , the extremity passes from x to q' , and the intersection from

C to q , Oq^2 being $= \frac{Oc^2}{2}$. 8. While the contact of the ruler and caustic shifts from z to v , the extremity shifts from q' to y , and the intersection from q to O. 9. The contact rises from v to d , the extremity passes from y to f , and the intersection from O to C; and then the motion across the refracting surface is completed, the point of contact shifting down from D to I, along the branch DVZCI, and then ascending along the other branch I $c v d$, while the intersection passes from c to C, back again from O to c , and then back again from c to C, where it ends, having thrice passed through every intermediate point of c C.

We may form a notion of the density of the light in any point H, by supposing the incident light of uniform density at the refracting surface, and attending to the constipation of the rays in the circle of smallest diffusion. Their vicinity may be estimated both in the direction of the radii OH, and in the direction of the circumference described by its extremity H, during its revolution round the axis; and the density must be conceived as proportional to the number of originally equidistant rays, which are collected into a spot of given area. These have been collected from a corresponding spot or area of the refracting surface; and as the number of rays is the same in both, the density at H will be to the density of the refracting surface, as the area occupied of the refracting surface to the corresponding area at H. The vicinity of the rays in the direction of the radius depends on the proportion between PT and TH. For the ray adjacent to PTH may be supposed to cross it at the point of contact T; and therefore the uniform distance between them at the surface of that medium is to the distance between the same rays at H as the distance of T from the refracting surface to its distance from H. Therefore the number of rays which occupy a tenth of an inch, for example, of the radius AP, is to the number which would occupy a tenth of an inch at H as TH to TP; and the radial density at P is to the radial density at H also as TH to TP. In the next place, the circumferential density at P is to that at H as the radius AP to the radius OH. For supposing the figure to turn round its axis AI, the point P of the refracting surface will describe a circumference whose radius is AP, and H will describe a circumference whose radius is OH; and the whole rays which pass through the first circumference pass also thro' the last; and therefore their circumferential densities will be in the inverse proportion of the spaces into which they are collected. Now the radius AP is to the radius OH as AL to OL; and circumferences have the same proportion with their radii. Therefore the circumferential density at P is to that in H as AL to OL inversely; and it was found that the radial density was as AN to ON inversely, being as TH to TP, which are very nearly in this ratio. Therefore the absolute density (or number of rays collected in a given space) at P will be to that at H, in the ratio compounded of these ratios; that is, in the ratio of ON $\times$ OL to AN $\times$ AL. But as NL bears but a very small ratio to AN or AL,

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ANXAL may be taken as equal to AO^2 without any sensible error. It never differs from it in telescopes, 100th part, and is generally incomparably smaller. Therefore the density at H may be considered as proportional to $ON \times OL$ inversely. And it will afterwards appear that NS is $= 30L$. Therefore the density at H is inversely as $ON \times NS$.

Now describe a circle on the diameter OS, and draw NT cutting the circumference $N^2 = ON \times NS$, and the density at H is as N^2 inversely. This gives us a very easy estimation of the density, viz. draw a line from the point of contact of the ray which touches the part VC of the caustic, and the density is in the inverse subduplicate ratio of the part of this line intercepted between the axis and the circumference S_2O . It will afterwards appear that the density corresponding to this ray is one half of the density corresponding to all the three: or a better expression will be had for the density at H by drawing $R\beta$ perpendicular to $R\tau$, and βo perpendicular to $\phi\beta$, making ϕR in o ; then ϕo is as $\frac{1}{\phi N^2}$, or is proportional to the density, as is evident.

When H is at O, N is at S, and ϕo is infinite. As H moves from O, N descends, and ϕo diminishes, till H comes to Q, and T to z, and ϕ to ζ , and o to R. When H moves from Q towards C, T descends below z, ϕo again increases, till it is again infinite, when H is at C, T at C, and N at O.

Thus it appears, without any minute consideration, that the light has a density indefinitely great in the centre O; that the density decreases to a minimum in some intermediate point Q, and then increases again to infinity at the margin C. Hence it follows, that the indistinctness arising from the spherical figure of the refracting surfaces is incomparably greater than Newton supposed; and that the valuable discovery of Mr Dollond of achromatic lenses, must have failed of answering his fond expectations, if his very method of producing them had not, at the same time, enabled him to remove that other indistinctness by employing contrary aberrations. And now, since the discoveries by Dr Blair of substances which disperse the different colours in the same proportions, but very different degrees, has enabled us to employ much larger portions of the sphere than Mr Dollond could introduce into his object-glasses, it becomes absolutely necessary to study this matter completely, in order to discover and ascertain the amount of the errors which perhaps unavoidably remain.

This slight sketch of the most simple case of aberration, namely, when the incident rays are parallel, will serve to give a general notion of the subject; and the reader can now see how contrary aberrations may be employed in order to form an ultimate image which shall be as distinct as possible. For let it be proposed to converge parallel rays accurately to the focus F (fig. 3.) by the refraction of spherical surfaces of which V is the vertex. Let PV be a convex lens of such a form that rays flowing from F and passing through it immediately round the vertex V are collected to the conjugate focus R, while the extreme ray FP, incident on the margin of the lens P, is converged to r , nearer to V, having the longitudinal aberration Rr . Let pV be a plano-concave lens, of such sphericity

that a ray Ap , parallel to the axis CV, and incident on the point p , as far from its vertex V as P in the other lens is from its vertex, is dispersed from r , the distance pV being equal to rV , while the central rays are dispersed from P, as far from V as R is from V. It is evident, that if these lenses be joined as in fig. 4. a ray $A'p$, parallel to the common axis CV, will be collected at the distance VF equal to VF in the fig. 4. and that rays passing through both lenses in the neighbourhood of the axis will be collected at the same point F.

This compound lens is said to be without spherical aberration; and it is true that the central and the extreme rays are collected in the same point F: but the rays which fall on the lens between the centre and margin are a little diffused from F, and it is not possible to collect them all to one point. For in the rules for computing the aberration, quantities are neglected which do not preserve (in different apertures) the same ratio to the quantities retained. The diffusion is least when the aberration is corrected, not for the very extremity, but for a certain intermediate point (varying with the aperture, and having no known ratio to it); and when this is done the compound lens is in its state of greatest perfection, and the remaining aberration is quite insensible.

This subject will be resumed under the article TELESCOPE, and prosecuted as far as the construction of optical instruments requires.

SECT. IV. Of Optical Instruments.

OF the mechanism of optical instruments particular accounts are given in this work under their respective denominations. These it would be improper to repeat: but as it belongs to the science of optics to explain, by the laws of refraction and reflection, the several phenomena which those instruments exhibit, we must in this place enumerate the instruments themselves, omitting entirely, or stating very briefly, such facts as are stated at large in other places. In this enumeration we shall begin with the *multiplying-glass*, not because it is first in importance, but that it may not intervene between instruments more useful, and which have a mutual relation to one another.

§ 1. The Multiplying-glass.

THE multiplying-glass is made by grinding down the round side bik (fig. 1.) of a plano-convex glass AB, into several flat surfaces, as bb , bld , dk . An object C will not appear magnified when seen through this glass by the eye at H; but it will appear multiplied into as many different objects as the glass contains plane surfaces. For, since rays will flow from the object C to all parts of the glass, and each plane surface will refract these rays to the eye, the same object will appear to the eye in the direction of the rays which enter it through each surface. Thus, a ray giH , falling perpendicularly on the middle surface, will go through the glass to the eye without suffering any refraction; and will therefore show the object in its true place at C: whilst a ray ab flowing from the same object, and falling obliquely on the plane surface bb , will be refracted in the direction be , by passing through the glass; and, upon leaving it, will go on to the eye in the direction eH ; which will

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multiplying-glass.

cause

255
Contrary
aberrations
correct
each other.

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Fig. 3.

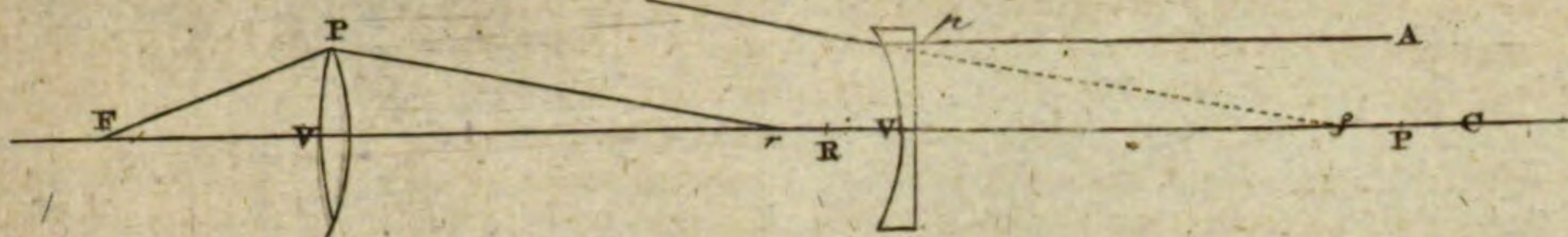


Fig. 2.

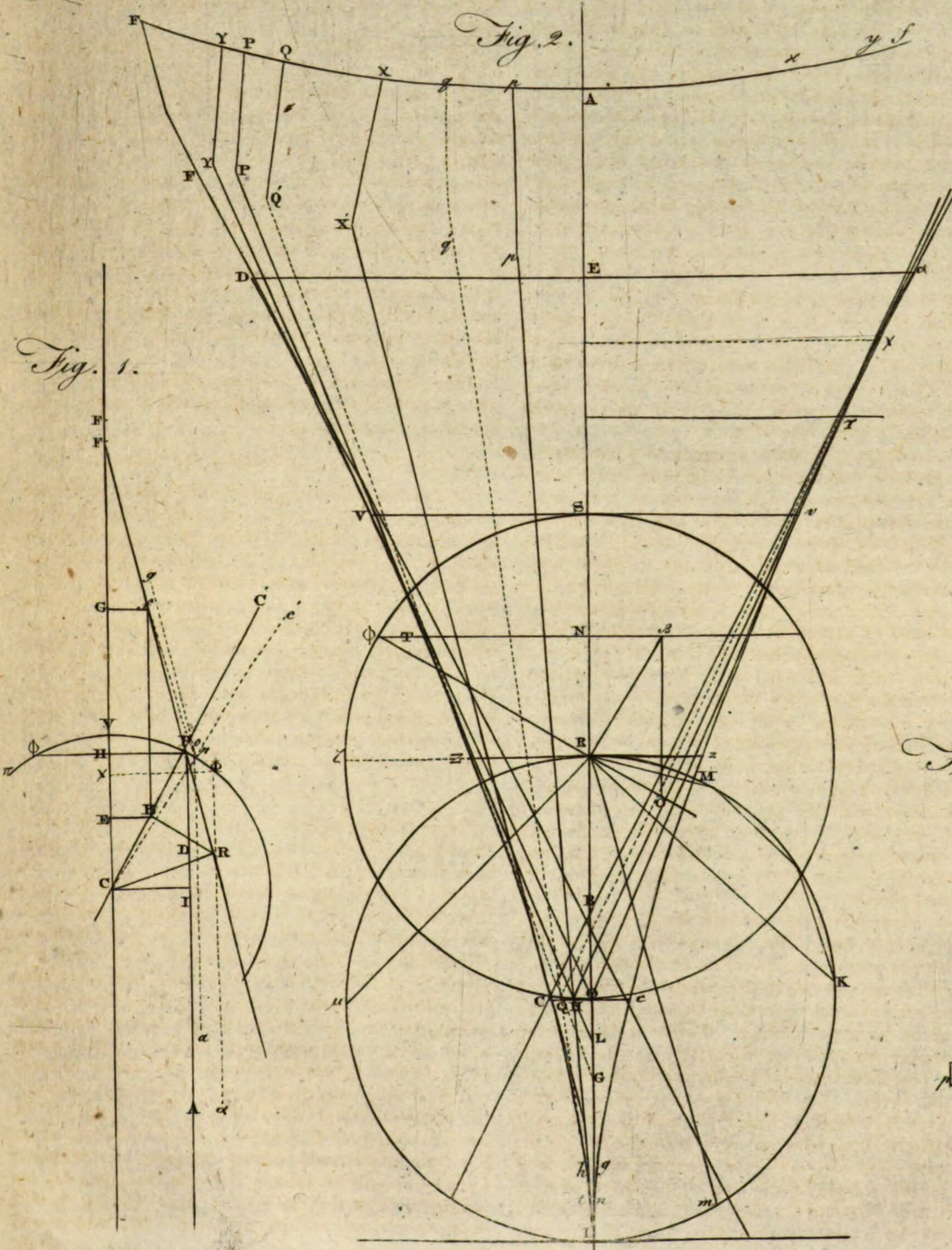


Fig. 1.

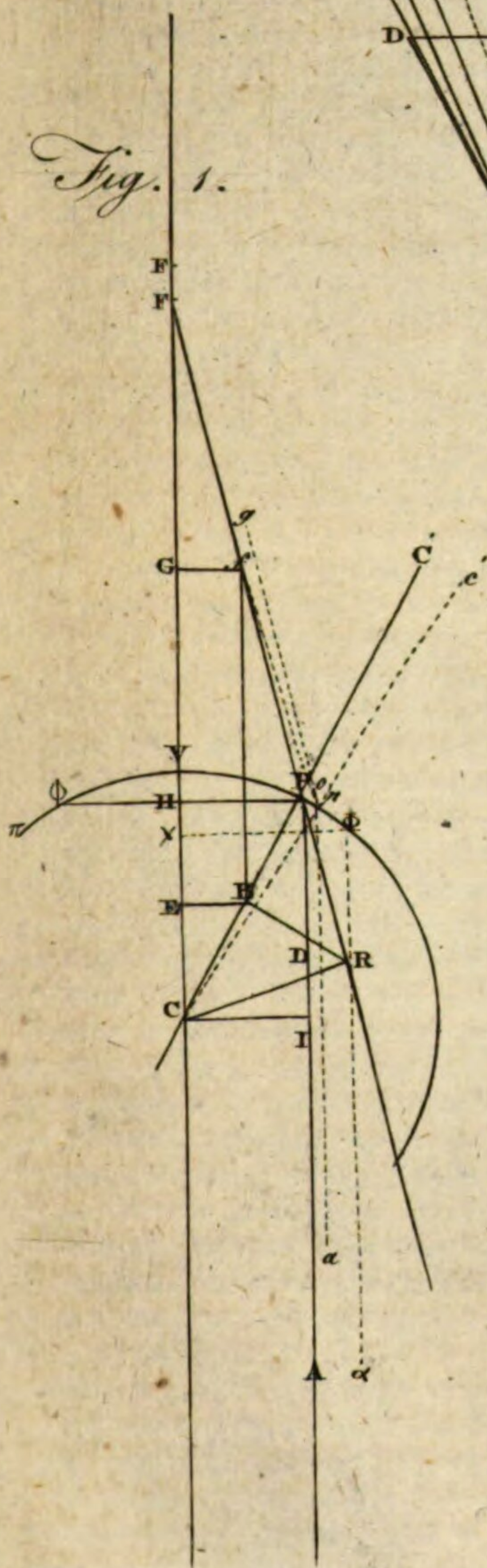
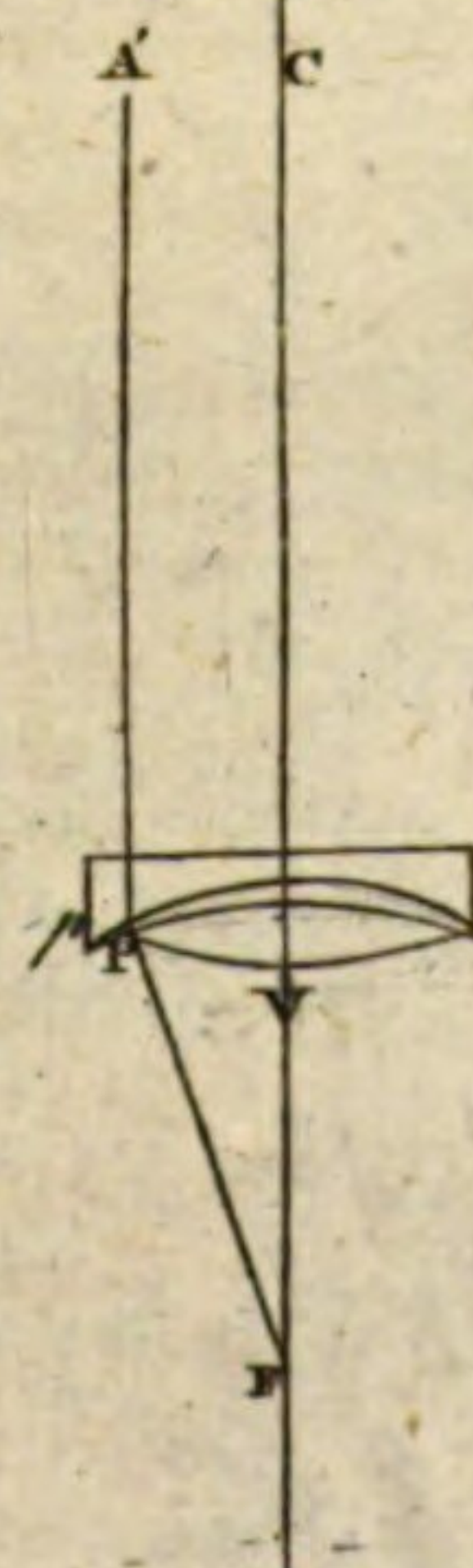


Fig. 4.



Plane
Mirrors.

cause the same object *C* to appear also at *E*, in the direction of the ray *He*, produced in the right line *Hen*. And the ray *cd*, flowing from the object *C*, and falling obliquely on the plane surface *dk*, will be refracted (by passing through the glass, and leaving it at *f*) to the eye at *H*; which will cause the same object to appear at *D*, in the direction *Hfm*.—If the glass be turned round the line *g/H*, as an axis, the object *C* will keep its place, because the surface *b/d* is not removed; but all the other objects will seem to go round *C*, because the oblique planes, on which the rays *abcd* fall, will go round by the turning of the glass.

§ 2. Mirrors.

It has been elsewhere observed, that of mirrors there are three principally used in optical experiments (See CATOPTICS, Sect. I.); the plane mirror, the spherical convex mirror, and the spherical concave mirror. Of these the plane mirror first claims our attention, as it is more common, and undoubtedly more ancient, than the other two. It has been said (*ubi supra*), that the image reflected by this mirror appears as far behind the surface as the object is before it; that the image will appear of the same size, and in the same position with the object; that every such mirror will reflect an image of twice its own length and breadth; and that in certain circumstances it will reflect several images of the same object. For these phenomena it is our business in this place to account by the laws of reflection.

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Let *AB* (fig. 2.) be an object placed before the reflecting surface *ghi* of the plane mirror *CD*; and let the eye be at *o*. Let *Ab* be a ray of light flowing from the top *A* of the object, and falling upon the mirror at *b*, and *bm* be a perpendicular to the surface of the mirror at *b*; the ray *Ab* will be reflected from the mirror to the eye at *o*, making an angle *mbo* equal to the angle *Abm*: then will the top of the image *E* appear to the eye in the direction of the reflected ray *ob* produced to *E*, where the right line *ApE*, from the top of the object, cuts the right line *obE*, at *E*. Let *Bi* be a ray of light proceeding from the foot of the object at *B* to the mirror at *i*; and *ni* a perpendicular to the mirror from the point *i*, where the ray *Bi* falls upon it: this ray will be reflected in the line *io*, making an angle *nio* equal the angle *Bin*, with that perpendicular, and entering the eye at *o*; then will the foot *F* of the image appear in the direction of the reflected ray *oi*, produced to *F*, where the right line *BF* cuts the reflected ray produced to *F*. All the other rays that flow from the intermediate points of the object *AB*, and fall upon the mirror between *b* and *i*, will be reflected to the eye at *o*; and all the intermediate points of the image *EF* will appear to the eye in the direction of these reflected rays produced. But all the rays that flow from the object, and fall upon the mirror above *b*, will be reflected back above the eye at *o*; and all the rays that flow from the object, and fall upon the mirror below *i*, will be reflected back below the eye at *o*; so that none of the rays that fall above *b*, or below *i*, can be reflected to the eye at *o*; and the distance between *b* and *i* is equal to half the length of the object *AB*.

Hence it appears, that if a man sees his whole

image in a plane looking-glass, the part of the glass that reflects his image must be just half as long and half as broad as himself, let him stand at any distance from it whatever; and that his image must appear just as far behind the glass as he is before it. Thus, the man *AB* (fig. 3.) viewing himself in the plane mirror *CD*, which is just half as long as himself, sees his whole image as at *EF*, behind the glass, exactly equal to his own size. For a ray *AC* proceeding from his eye at *A*, and falling perpendicularly upon the surface of the glass at *C*, is reflected back to his eye, in the same line *CA*; and the eye of his image will appear at *E*, in the same line produced to *E*, beyond the glass. And a ray *BD*, flowing from his foot, and falling obliquely on the glass at *D*, will be reflected as obliquely on the other side of the perpendicular *abD*, in the direction *DA*; and the foot of his image will appear at *F*, in the direction of the reflected ray *AD*, produced to *F*, where it is cut by the right line *BGF*, drawn parallel to the right line *ACE*. Just the same as if the glass were taken away, and a real man stood at *F*, equal in size to the man standing at *B*: for to his eye at *A*, the eye of the other man at *E* would be seen in the direction of the line *ACE*; and the foot of the man at *F* would be seen by the eye *A*, in the direction of the line *ADF*.

If the glass be brought nearer the man *AB*, as suppose to *cb*, he will see his image as at *CDG*: for the reflected ray *CA* (being perpendicular to the glass) will show the eye of the image as at *C*; and the incident ray *Bb*, being reflected in the line *bA*, will show the foot of his image as at *G*; the angle of reflection *abA* being always equal to the angle of incidence *Bba*: and so of all the intermediate rays from *A* to *B*. Hence, if the man *AB* advances towards the glass *CD*, his image will approach towards it; and if he recedes from the glass, his image will also recede from it.

If the object be placed before a common looking-glass, and viewed obliquely, three, four, or more images of it, will appear behind the glass.

To explain this, let *ABCD* (fig. 11.) represent the glass; and let *EF* be the axis of a pencil of rays flowing from *E*, a point in an object situated there. The rays of this pencil will in part be reflected at *F*, suppose into the line *FG*. What remains will (after refraction at *F*, which we do not consider here) pass on to *H*; from whence (on account of the quicksilver which is spread over the second surface of glasses of this kind to prevent any of the rays from being transmitted there) they will be strongly reflected to *K*, where part of them will emerge and enter an eye at *L*. By this means one representation of the said point will be formed in the line *LK* produced, suppose in *M*; Again, another pencil, whose axis is *EN*, first reflected at *N*, then at *O*, and afterwards at *P*, will form a second representation of the same point at *Q*: And thirdly, another pencil, whose axis is *ER*, after reflection at the several points *R*, *S*, *H*, *T*, *V*, successively, will exhibit a third representation of the same point at *X*; and so on *in infinitum*. The same being true of each point in the object, the whole will be represented in the like manner; but the representations will be faint, in proportion to the number of reflections the rays suffer, and the length of their progress within the

X x 2

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or four
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objects are
seen in
plane mirrors.

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and Convex
Mirrors.

glass. We may add to these another representation of the same object in the line LO produced, made by such of the rays as fall upon O, and are from thence reflected to the eye at L.

This experiment may be tried by placing a candle before the glass as at E, and viewing it obliquely, as from L.

2. Of Concave and Convex Mirrors. The effects of these in magnifying and diminishing objects have been already in general explained; but for the better understanding the nature of reflecting telescopes, it will still be proper to subjoin the following particular description of the effects of concave ones.

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When parallel rays (fig. 4.), as dfa , Cmb , elc , fall upon a concave mirror AB (which is not transparent, but has only the surface AB of a clear polish), they will be reflected back from that mirror, and meet in a point m , at half the distance of the surface of the mirror from C the centre of its concavity; for they will be reflected at as great an angle from a perpendicular to the surface of the mirror, as they fell upon it with regard to that perpendicular, but on the other side thereof. Thus, let C be the centre of concavity of the mirror AB ; and let the parallel rays dfa , Cmb , and elc , fall upon it at the points a , b , and c . Draw the lines Cia , Cmb , and Cbc , from the centre C to these points; and all these lines will be perpendicular to the surface of the mirror, because they proceed thereto like so many radii or spokes from its centre. Make the angle Cab equal to the angle dac , and draw the line amb , which will be the direction of the ray dfa , after it is reflected from the point a of the mirror: so that the angle of incidence dac is equal to the angle of reflection Cab ; the rays making equal angles with the perpendicular Cia on its opposite sides.

Draw also the perpendicular Cbc to the point c , where the ray elc touches the mirror; and having made the angle Cci equal to the angle Cce , draw the line cmi , which will be the course of the ray elc , after it is reflected from the mirror.

The ray Cmb passing through the centre of concavity of the mirror, and falling upon it at b , is perpendicular to it; and is therefore reflected back from it in the same line bmc .

All these reflected rays meet in the point m ; and in that point the image of the body which emits the parallel rays da , Cb , and ec , will be formed; which point is distant from the mirror equal to half the radius bmc of its concavity.

The rays which proceed from any celestial object may be esteemed parallel at the earth; and therefore the image of that object will be formed at m , when the reflecting surface of the concave mirror is turned directly towards the object. Hence, the focus m of parallel rays is not in the centre of the mirror's concavity, but half way between the mirror and that centre.

The rays which proceed from any remote terrestrial object are nearly parallel at the mirror: not strictly so, but come diverging to it, in separate pencils, or as it were bundles of rays, from each point of the side of the object next the mirror; and therefore they will not be converged to a point at the distance of half the radius of the mirror's concavity from its reflecting sur-

face, but into separate points at a little greater distance from the mirror. And the nearer the object is to the mirror, the farther these points will be from it; and an inverted image of the object will be formed in them, which will seem to hang pendant in the air; and will be seen by an eye placed beyond it (with regard to the mirror) in all respects like the object, and as distinct as the object itself.

Let AcB (fig. 5.) be the reflecting surface of a mirror, whose centre of concavity is at C; and let the upright object DE be placed beyond the centre C, and send out a conical pencil of diverging rays from its upper extremity D, to every point of the concave surface of the mirror AcB . But to avoid confusion, we only draw three rays of that pencil, as DA, Dc, DB.

From the centre of concavity C, draw the three right lines CA, Cc, CB, touching the mirror in the same points where the foresaid rays touch it; and all these lines will be perpendicular to the surface of the mirror. Make the angle CAd equal to the angle DAC, and draw the right line Ad for the course of the reflected ray DA: make the angle Ccd equal to the angle DcC, and draw the right line cd for the course of the reflected ray Dd: make also the angle CBd equal to the angle DBC, and draw the right line Bd for the course of the reflected ray DB. All these reflected rays will meet in the point d , where they will form the extremity d of the inverted image ed , similar to the extremity D of the upright object DE.

If the pencil of rays Ef, Eg, Eb, be also continued to the mirror, and their angles of reflection from it be made equal to their angles of incidence upon it, as in the former pencil from D, they will all meet at the point e by reflection, and form the extremity e of the image ed , similar to the extremity E of the object DE.

And as each intermediate point of the object, between D and E, sends out a pencil of rays in like manner to every part of the mirror, the rays of each pencil will be reflected back from it, and meet in all the intermediate points between the extremities e and d of the image; and so the whole image will be formed, not at i , half the distance of the mirror from its centre of concavity C, but at a greater distance, between i and the object DE; and the image will be inverted with respect to the object.

This being well understood, the reader will easily see how the image is formed by the large concave mirror of the reflecting telescope, when he comes to the description of that instrument.

When the object is more remote from the mirror than its centre of concavity C, the image will be less than the object, and between the object and mirror: when the object is nearer than the centre of concavity, the image will be more remote and bigger than the object. Thus, if ED be the object, de will be its image: For, as the object recedes from the mirror, the image approaches nearer to it; and as the object approaches nearer to the mirror, the image recedes farther from it; on account of the lesser or greater divergency of the pencils of rays which proceed from the object: for the less they diverge, the sooner they are converged to points by reflection; and the more they

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they diverge, the farther they must be reflected before they meet.

If the radius of the mirror's concavity, and the distance of the object from it, be known, the distance of the image from the mirror is found by this rule: Divide the product of the distance and radius by double the distance made less by the radius, and the quotient is the distance required.

If the object be in the centre of the mirror's concavity, the image and object will be coincident, and equal in bulk.

If a man places himself directly before a large concave mirror, but farther from it than its centre of concavity, he will see an inverted image of himself in the air, between him and the mirror, of a less size than himself. And if he holds out his hand towards the mirror, the hand of the image will come out towards his hand, and coincide with it, of an equal bulk, when his hand is in the centre of concavity; and he will imagine he may shake hands with his image. If he reaches his hand farther, the hand of the image will pass by his hand, and come between his hand and his body: and if he moves his hand towards either side, the hand of the image will move towards the other; so that whatever way the object moves, the image will move the contrary.

All the while a bystander will see nothing of the image, because none of the reflected rays that form it enter his eyes.

§ 3. Microscopes.

Under the word MICROSCOPE a copious detail has been given of the construction of those instruments as they are now made by the most eminent artists. In that article it fell not within our plan to treat scientifically of their magnifying powers: these can be explained only by the laws of refraction and reflection, which we shall therefore apply to a few microscopes, leaving our readers to make the application themselves to such others as they may choose to analyse by optical principles.

The first and simplest of all microscopes is nothing more than a very small globule of glass, or a convex lens whose focal distance is extremely short. The magnifying power of this microscope is thus ascertained by Dr Smith. "A minute object pq , seen distinctly through a small glass AE by the eye put close to it, appears so much greater than it would to the naked eye, placed at the least distance qL from whence it appears sufficiently distinct, as this latter distance qL is greater than the former qE . For having put your eye close to the glass EA , in order to see as much of the object as possible at one view, remove the object pq to and fro till it appear most distinctly, suppose at the distance Eq . Then conceiving the glass AE to be removed, and a thin plate, with a pin-hole in it, to be put in its place, the object will appear distinct, and as large as before, when seen through the glass, only not so bright. And in this latter case it appears so much greater than it does to the naked eye at the distance qL , either with the pin-hole or without it, as the angle pEq is greater than the angle pLq , or as the latter distance qL is greater than the former qE . Since the interposition of the glass has no other effect than to render the appearance distinct, by helping the eye to

increase the refraction of the rays in each pencil, it is plain that the greater apparent magnitude is entirely owing to a nearer view than could be taken by the naked eye. As the human eye is so constructed, as, for reasons already assigned, to have distinct vision only when the rays which fall upon it are parallel or nearly so; it follows, that if the eye be so perfect as to see distinctly by pencils of parallel rays falling upon it, the distance Eq , of the object from the glass, is then the focal distance of the glass. Now, if the glass be a small round globule, of about $\frac{1}{3}$ th of an inch diameter, its focal distance Eq , being three quarters of its diameter, is $\frac{1}{10}$ th of an inch; and if qL be eight inches, the distance at which we usually view minute objects, this globule will magnify in the proportion of 8 to $\frac{1}{10}$, or of 160 to 1.

2. The Double or Compound Microscope (fig. 8.) consists of an object-glass cd , and an eye-glass ef . The small object ab is placed at a little greater distance from the glass cd than its principal focus; so that the pencils of rays flowing from the different points of the object, and passing through the glass, may be made to converge, and unite in as many points between g and b , where the image of the object will be formed: which image is viewed by the eye through the eye-glass ef . For the eye-glass being so placed, that the image gb may be in its focus, and the eye much about the same distance on the other side, the rays of each pencil will be parallel after going out of the eye-glass, as at e and f , till they come to the eye at k , where they will begin to converge by the refractive power of the humours; and after having crossed each other in the pupil, and passed through the crystalline and vitreous humours, they will be collected into points on the retina, and form the large inverted image AB thereon.

By this combination of lenses, the aberration of the light from the figure of the glass, which in a globule of the kind above-mentioned is very considerable, is in some measure corrected. This appeared so sensibly to be the case, even to former opticians, that they very soon began to make the addition of another lens. The instrument, however, receives a considerable improvement by the addition of a third lens. For, says Mr Martin, it is not only evident from the theory of this aberration, that the image of any point is rendered less confused by refraction through two lenses than by an equal refraction through one; but it also follows, from the same principle, that the same point has its image still less confused when formed by rays refracted through three lenses than by an equal refraction through two; and therefore a third lens added to the other two will contribute to make the image more distinct, and consequently the instrument more complete. At the same time the field of view is amplified, and the use of the microscope rendered more agreeable, by the addition of the other lens. Thus also we may allow a somewhat larger aperture to the object-lens, and thereby increase the brightness of objects, and greatly heighten the pleasure of viewing them. For the same reason, Mr Martin has proposed a four-glass microscope, which answers the purposes of magnifying and of distinct vision still more perfectly.

The magnifying power of double microscopes is easily

Micro-
scopes.
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fig. 9.

fully understood, thus: The glass *L* next the object *PQ* is very small, and very much convex, and consequently its focal distance *LF* is very short; the distance *LQ* of the small object *PQ* is but a little greater than *LF*: Greater it must be, that the rays flowing from the object may converge after passing through the glass, and, crossing one another, form an image of the object; and it must be but a little greater, that the image *pq* may be at a great distance from the glass, and consequently may be much larger than the object itself. This picture *pq* being viewed through a convex glass *AE*, whose focal distance is *qE*, appears distinct as in a telescope. Now the object appears magnified upon two accounts; first, because, if we viewed its picture *pq* with the naked eye, it would appear as much greater than the object, at the same distance, as it really is greater than the object, or as much as *Lq* is greater than *LQ*: and, secondly, because this picture appears magnified through the eye-glass as much as the least distance at which it can be seen distinctly with the naked eye, is greater than *qE*, the focal distance of the eye-glass. For example, if this latter ratio be five to one, and the former ratio of *Lq* to *LQ* be 20 to 1; then, upon both accounts, the object will appear 5 times 20, or 100 times greater than to the naked eye.

Fig. 10. represents the section of a compound microscope with three lenses. By the middle one *GK* the pencils of rays coming from the object-glass are refracted so as to tend to a focus at *O*; but being intercepted by the proper eye-glass *DF*, they are brought together at *I*, which is nearer to that lens than its proper focus at *L*; so that the angle *DIF*, under which the object now appears, is larger than *DLF*, under which it would have appeared without this additional glass; and consequently the object is more magnified in the same proportion. Dr Hooke tells us, that, in most of his observations, he made use of a double microscope with this broad middle-glass when he wanted to see much of an object at one view, and taking it out when he would examine the small parts of an object more accurately; for the fewer refractions there are, the more bright and clear the object appears.

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The magnifying
power of
Dr Smith's
microscope.

Having in the historical part of this article given a practical account of the construction of Dr Smith's double reflecting microscope, it may not be improper in this place to ascertain its magnifying power. This we shall do from the author himself, because his symbols, being general, are applicable to such microscopes of all dimensions; and though the mere practical reader may perhaps be at first sight puzzled by them, yet, if he will substitute any particular numbers for *m* and *n*, &c. he may ascertain with ease the magnifying power of such a microscope of those particular dimensions.

Between the centre *E* and principal focus *T* of a concave speculum *ABC*, whose axis is *EQTC*, place an object *PQ*; and let the rays flowing from it be reflected from the speculum *AB* towards an image *pq*; but before they unite in it, let them be received by a convex speculum *abc*, and thence be reflected, through a hole *BC* in the vertex of the concave, to a second image *ωx*, to be viewed through an eye-glass *l*.

The object may be situated between the specula *C*, *c*; or, which is better, between the principal focus *I*

and vertex *c* of the convex one, a small hole being made in its vertex for the incident rays to pass through.

In both cases we have *TQ*, *TE*, *Tq*, continual proportionals in some given ratio, suppose of 1 to *n*; and also *iq*, *ic*, *ix*, continual proportionals in some other given ratio, suppose of 1 to *m*. Then if *d* be the usual distance at which we view minute objects distinctly with the naked eye, and *xl* the focal distance of the least eye-glass, through which the object appears sufficiently bright and distinct, it will be magnified in the ratio of *mnd* to *xl*.

For the object *PQ*, and its first image *pq*, are terminated on one side by the common axis of the specula, and on the other by a line *PEp*, drawn through the centre *E* of the concave *ABC*. Likewise the images *pq* and *ωx* are terminated by the common axis and by the line *epω*, drawn through the centre *c* of the convex *abc*. Hence, by the similar triangles *ωxe*, *pqe*, *Eucl. v. 12.* and also *pqE*, *PQE*, we have $\omega x : pq :: xe : qe :: m : 1$, and $pq : PQ :: qE : QE :: n : 1$; and consequently $\omega x : PQ :: mn : 1$, whence $\omega x = mn \times PQ$. Now if *lx* be the focal distance of the eye-glass *l*, the points *P*, *Q*, of the object, are seen through it by the rays of two pencils emerging parallel to the lines *ωl*, *xl* respectively; that is, *PQ* appears under an angle equal to ωlx , which is as $\frac{\omega x}{xl} = \frac{mnPQ}{xl}$; and to the naked eye at the distance *d* from *PQ*, it appears under an angle *PoQ* which is as $\frac{PQ}{d}$, and therefore is magnified in the ratio of these angles, that is, of *mnd* to *xl*.

Corol. Having the numbers *m*, *n*, *d*, to find an eye-glass which shall cause the microscope to magnify *M* times in diameter, take $xl = \frac{mnd}{M}$. For the appa-

rent magnitude is to the true as *M* : 1 :: *mnd* : *xl*.

We shall conclude this part of our subject with the following easy method of ascertaining the magnifying power of such microscopes as are most in use. 262
An easy method of ascertaining the magnifying power of the most common microscopes.

The apparent magnitude of any object, as must appear from what hath been already delivered, is measured by the angle under which it is seen; and this angle is greater or smaller according as the object is near to or far from the eye; and of consequence the less the distance at which it can be viewed the larger it will appear. The naked eye is unable to distinguish any object brought exceedingly near it: but looking through a convex lens, however near the focus of that lens be, there an object may be distinctly seen; and the smaller the lens is, the nearer will be its focus, and in the same proportion the greater will be its magnifying power. From these principles it is easy to find the reason why the first or greatest magnifiers are so extremely minute; and also to calculate the magnifying power of any convex lens employed in a single microscope: For as the proportion of the natural sight is to the focus, such will be its power of magnifying. If the focus of a convex lens, for instance, be at one inch, and the natural sight at eight inches, which is the common standard, an object may be seen through that lens at one inch distance from the eye, and will appear in its diameter eight times larger than

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scopes.

than it does to the naked eye: but as the object is magnified every way, in length as well as in breadth, we must square this diameter to know how much it really is enlarged; and we then find that its superficies is magnified 64 times.

Again, suppose a convex lens whose focus is only one-tenth of an inch distant from its centre; as in eight inches, the common distance of distinct vision with the naked eye, there are 80 such tenths, an object may be seen through this glass 80 times nearer than with the naked eye. It will, of consequence, appear 80 times longer, and as much broader, than it does to common sight; and therefore is 6400 times magnified. If a convex glass be so small that its focus is only $\frac{1}{80}$ of an inch distant, we find that eight inches contains 160 of these twentieth-parts; and of consequence the length and breadth of any object seen through such a lens will be magnified 160 times, and the whole surface 25,600 times. As it is an easy matter to melt a drop or globule of a much smaller diameter than a lens can be ground, and as the focus of a globule is no farther off than a quarter of its own diameter, it must of consequence magnify to a prodigious degree. But this excessive magnifying power is much more than counterbalanced by its admitting so little light, want of distinctness, and showing such a minute part of the object to be examined; for which reason, these globules, though greatly in vogue some time ago, are now almost entirely rejected. Mr Leeuwenhoek, as has been already observed, made use only of single microscopes consisting of convex lenses, and left to the Royal Society a legacy of 26 of those glasses. According to Mr Folke's description of these, they were all exceedingly clear, and showed the object very bright and distinct; "which (says Mr Folkes) must be owing to the great care this gentleman took in the choice of his glass, his exactness in giving it the true figure, and afterwards, among many, reserving only such for his use as upon trial he found to be most excellent. Their powers of magnifying are different, as different objects may require: and as on the one hand, being all ground glasses, none of them are so small, or consequently magnify

to so great a degree, as some of those drops frequently used in other microscopes; yet, on the other hand, the distinctness of these very much exceeds what I have met with in glasses of that sort. And this was what Mr Leeuwenhoek ever proposed to himself; rejecting all those degrees of magnifying in which he could not so well obtain that end. For he informs us in one of his letters, that though he had above 40 years by him glasses of an extraordinary smallness, he had made but very little use of them; as having found, in a long course of experience, that the most considerable discoveries were to be made with such glasses as, magnifying but moderately, exhibited the object with the greatest brightness and distinction."

In a single microscope, if you want to learn the magnifying power of any glass, no more is necessary than to bring it to its true focus, the exact place whereof will be known by an object's appearing perfectly distinct and sharp when placed there. Then, with a pair of small compasses, measure, as nearly as you can, the distance from the centre of the glass to the object you was viewing, and afterwards applying the compasses to any ruler, with a diagonal scale of the parts of an inch marked on it, you will easily find how many parts of an inch the said distance is. When that is known, compute how many times those parts of an inch are contained in eight inches, the common standard of sight, and that will give you the number of times the diameter is magnified: squaring the diameter will give the superficies; and, if you would learn the solid contents, it will be shown by multiplying the superficies by the diameter.

The superficies of one side of an object only can be seen at one view; and to compute how much that is magnified, is most commonly sufficient: but sometimes it is satisfactory to know how many minute objects are contained in a larger; as suppose we desire to know how many animalcules are contained in the bulk of a grain of sand: and to answer this, the cube, as well as the surface, must be taken into the account. For the greater satisfaction of those who are not much versed in these matters, we shall here subjoin the following

TABLE

TABLE of the MAGNIFYING POWERS of CONVEX GLASSES, employed in *Single Microscopes*, according to the distance of their focus; Calculated by the scale of an inch divided into 100 parts. Showing how many times the DIAMETER, the SUPERFICIES, and the CUBE of an OBJECT, is magnified, when viewed through such glasses, to an eye whose natural sight is at eight inches, or 800 of the 1000th-parts of an inch.

The focus of a glass at	Magnifies the Dia- meter.	Magnifies the Super- ficies.	Magnifies the Cube of an Object.	Times.
$\frac{1}{2}$, or 50	16	256	4,096	
$\frac{4}{10}$, or 40	20	400	8,000	
$\frac{1}{8}$, or 30	26	676	17,576	
$\frac{1}{5}$, or 20	40	1,600	64,000	
15	53	2,809	148,877	
14	57	3,249	185,193	
13	61	3,721	226,981	
12	66	4,356	287,496	
11	72	5,184	373,248	
$\frac{1}{10}$, or 10	80	6,400	512,000	
9	88	7,744	681,472	
8	100	10,000	1,000,000	
7	114	12,996	1,481,544	
6	133	17,689	2,352,637	
$\frac{1}{5}$, or 5	160	25,600	4,096,000	
4	200	40,000	8,000,000	
3	266	70,756	18,821,096	
$\frac{1}{2}$, or 2	400	160,000	64,000,000	
1	800	640,000	512,000,000	

The greatest magnifier in Mr Leeuwenhoek's cabinet of microscopes, presented to the Royal Society, has its focus, as nearly as can well be measured, at one-twentieth of an inch distance from its centre; and consequently magnifies the diameter of an object 160 times, and the superficies 25,600. But the greatest magnifier in Mr Wilson's single microscopes, as they are now made, has usually its focus at no farther distance than about the 50th part of an inch; whereby it has a power of enlarging the diameter of an object 400, and its superficies 160,000 times.

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The mag-
nifying
power of
the solar
microscope
calculated
differently
from that
of others.

The magnifying power of the solar microscope must be calculated in a different manner; for here the difference between the focus of the magnifier and the distance of the screen or sheet whereon the image of the object is cast, is the proportion of its being magnified. Suppose, for instance, the lens made use of has its focus at half an inch, and the screen is placed at the distance of five feet, the object will then appear magnified in the proportion of five feet to half an inch: and as in five feet there are 120 half inches, the diameter will be magnified 120 times, and the superficies 14,400 times; and, by putting the screen at farther distances, you may magnify the object almost as much as you please; but Mr Baker advises to regard distinctness more than bigness, and to place the screen just at that distance where the object is seen most distinct and clear.

With regard to the double reflecting microscope, Mr Baker observes, that the power of the object-lens is indeed greatly increased by the addition of two eye-glasses; but as no object-lens can be used with them of so minute a diameter, or which magnifies of itself near so much as those that can be used alone, the glasses of this microscope, upon the whole, magnify little or nothing more than those of Mr Wilson's single
N^o 249.

one; the chief advantage arising from a combination of lenses being the sight of a larger field or portion of an object magnified in the same degree.

§ 4. Telescopes.

I. The REFRACTING TELESCOPE.

AFTER what has been said concerning the structure of the compound microscope, and the manner in which the rays pass through it to the eye, the nature of the common astronomical telescope will easily be understood: for it differs from the microscope only in that the object is placed at so great a distance from it, that the rays of the same pencil, flowing from thence, may be considered as falling parallel to one another upon the object-glass; and therefore the image made by that glass is looked upon as coincident with its focus of parallel rays.

1. This will appear very plain from the 12th figure, in which AB is the object emitting the several pencils of rays Acd, Bcd, &c. but supposed to be at so great a distance from the object-glass cd, that the rays of the same pencil may be considered as parallel to each other; they are therefore supposed to be collected into their respective foci at the points m and p, situated at the focal distance of the object-glass cd. Here they form an image E, and crossing each other proceed diverging to the eye-glass bg; which being placed at its own focal distance from the points m and p, the rays of each pencil, after passing through that glass, will become parallel among themselves; but the pencils themselves will converge considerably with respect to one another, even so as to cross at e, very little farther from the glass gb than its focus; because, when they entered the glass, their axes were almost parallel, as coming through the object-glass at the point k, to
whose

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Nature of
the astrono-
mical te-
lescope.Plate
CCCLXIV

Refracting
Telescope.

266
Magnify-
ing power
of.

whose distance the breadth of the eye-glass in a long telescope bears very small proportion. So that the place of the eye will be nearly at the focal distance of the eye-glass, and the rays of each respective pencil being parallel among themselves, and their axes crossing each other in a larger angle than they would do if the object were to be seen by the naked eye, vision will be distinct, and the object will appear magnified.

The power of magnifying in this telescope is as the focal length of the object-glass to the focal length of the eye-glass.

DEM. In order to prove this, we may consider the angle AkB as that under which the object would be seen by the naked eye; for in considering the distance of the object, the length of the telescope may be omitted, as bearing no proportion to it. Now the angle under which the object is seen by means of the telescope is geb , which is to the other AkB , or its equal gkb , as the distance from the centre of the object-glass to that of the eye-glass. The angle, therefore, under which an object appears to an eye assisted by a telescope of this kind, is to that under which it would be seen without it, as the focal length of the object-glass to the focal length of the eye-glass.

It is evident from the figure, that the visible area, or space which can be seen at one view when we look through this telescope, depends on the breadth of the eye-glass, and not of the object-glass; for if the eye-glass be too small to receive the rays gm , pb , the extremities of the object could not have been seen at all: a larger breadth of the object-glass conduces only to the rendering each point of the image more luminous by receiving a larger pencil of rays from each point of the object.

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Objects seen
through,
inverted.

It is in this telescope as in the compound microscope, where we see, when we look through it, not the object itself, but only an image of it at CED : now that image being inverted with respect to the object, as it is, because the axes of the pencils that flow from the object cross each other at k , objects seen through a telescope of this kind necessarily appear inverted.

This is a circumstance not at all regarded by astronomers: but for viewing objects upon the earth, it is convenient that the telescope should represent them in their natural posture; to which use the telescope with three eye-glasses, as represented fig. 13. is peculiarly adapted, and the progress of the rays through it from the object to the eye is as follows:

Plate
CCCLXIV

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Common
refracting
telescope
shows ob-
jects erect.

AB is the object sending out the several pencils Acd , Bcd , &c. which passing through the object-glass cd , are collected into their respective foci in CD , where they form an inverted image. From hence they proceed to the first eye-glass ef , whose focus being at l , the rays of each pencil are rendered parallel among themselves, and their axes, which were nearly parallel before, are made to converge and cross each other: the second eye-glass gh , being so placed that its focus shall fall upon m , renders the axes of the pencils which diverge from thence parallel, and causes the rays of each, which were parallel among themselves, to meet again at its focus EF on the other side, where they form a second image inverted with respect to the former, but erect with respect to the object. Now this image being seen by the eye at ab through the eye-glass ik , affords a direct representation of the object, and under the same angle that the first image CD

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would have appeared, had the eye been placed at l , supposing the eye-glasses to be of equal convexity; and therefore the object is seen equally magnified in this as in the former telescope, that is, as the focal distance of the object-glass to that of any one of the eye-glasses, and appears erect.

If a telescope exceeds 20 feet, it is of no use in viewing objects upon the surface of the earth; for if it magnifies above 90 or 100 times, as those of that length usually do, the vapours which continually float near the earth in great plenty, will be so magnified as to render vision obscure.

2. The Galilean Telescope with the concave eye-glass is constructed as follows:

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Galilean
telescope,

AB (fig. 1.) is an object sending forth the pencils of rays ghi , k/m , &c. which, after passing through the object-glass cd , tend towards eEf (where we will suppose the focus of it to be), in order to form an inverted image there as before; but in their way to it are made to pass through the concave glass no , so placed that its focus may fall upon E , and consequently the rays of the several pencils which were converging towards those respective focal points e , E , f , will be rendered parallel among themselves: but the axes of those pencils crossing each other at F , and diverging from thence, will be rendered more diverging, as represented in the figure. Now these rays entering the pupil of an eye, will form a large and distinct image ab upon the retina, which will be inverted with respect to the object, because the axis of the pencils cross in F . The object of course will be seen erect, and the angle under which it will appear will be equal to that which the lines aF , bF , produced back through the eye-glass, form at F .

It is evident, that the less the pupil of the eye is, the less is the visible area seen through a telescope of this kind; for a less pupil would exclude such pencils as proceed from the extremities of the object AB , as is evident from the figure. This is an inconvenience that renders this telescope unfit for many uses; and is only to be remedied by the telescope with the convex eye-glasses, where the rays which form the extreme parts of the image are brought together in order to enter the pupil of the eye, as explained above.

It is apparent also, that the nearer the eye is placed to the eye-glass of this telescope, the larger is the area seen through it; for, being placed close to the glass, as in the figure, it admits rays that come from A and B , the extremities of the object, which it could not if it was placed farther off.

The degree of magnifying in this telescope is in the same proportion with that in the other, viz. as the focal distance of the object-glass is to the focal distance of the eye-glass.

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For there is no other difference but this, viz. that as the extreme pencils in that telescope were made to converge and form the angle geb (fig. 12.), or ink (fig. 13.), these are now made to diverge and form the angle aFb (fig. 1.); which angles, if the concave glass in one has an equal refractive power with the convex one in the other, will be equal, and therefore each kind will exhibit the object magnified in the same degree.

There is a defect in all these kinds of telescopes, not to be remedied in a single lens by any means whatever, which was thought only to arise from hence,

Y y

viz.

Plate
CCCLXV.

Plate
CCCLXIV
Plate
CCCLXV.

Refracting
Telescope.

Refracting
Telescope.

viz. that spherical glasses do not collect rays to one and the same point. But it was happily discovered by Sir Isaac Newton, that the imperfection of this sort of telescope, so far as it arises from the spherical form of the glasses, bears almost no proportion to that which is owing to the different refrangibility of light. This diversity in the refraction of rays is about a 28th part of the whole; so that the object-glass of a telescope cannot collect the rays which flow from any one point in the object into a less room than the circular space whose diameter is about the 56th part of the breadth of the glass.

Plate
CCCLXV.

To show this, let AB (fig. 2.) represent a convex lens, and let CDF be a pencil of rays flowing from the point D; let H be the point at which the least refrangible rays are collected to a focus; and I, that where the most refrangible concur. Then, if IH be the 28th part of EH, IK will be a proportionable part of EC (the triangles HIK and HEC being similar): consequently LK will be the 28th part of FC. But MN will be the least space into which the rays will be collected, as appears by their progress represented in the figure. Now MN is but about half of KL; and therefore it is about the 56th part of CF: so that the diameter of the space into which the rays are collected will be about the 56th part of the breadth of that part of the glass through which the rays pass; which was to be shown.

Since therefore each point of the object will be represented in so large a space, and the centres of those spaces will be contiguous, because the points in the object the rays flow from are so; it is evident, that the image of an object made by such a glass must be a most confused representation, though it does not appear so when viewed through an eye-glass that magnifies in a moderate degree; consequently the degree of magnifying in the eye-glass must not be too great with respect to that of the object-glass, lest the confusion become sensible.

Notwithstanding this imperfection, a dioptrical telescope may be made to magnify in any given degree, provided it be of sufficient length; for the greater the focal distance of the object-glass is, the less may be the proportion which the focal distance of the eye-glass may bear to that of the object-glass, without rendering the image obscure. Thus, an object-glass, whose focal distance is about four feet, will admit of an eye-glass whose focal distance shall be little more than an inch, and consequently will magnify almost 48 times; but an object-glass of 40 feet focus will admit of an eye-glass of only four inches focus, and will therefore magnify 120 times; and an object-glass of 100 feet focus will admit of an eye-glass of little more than six inches focus, and will therefore magnify almost 200 times.

The reason of this disproportion in their several degrees of magnifying is to be explained in the following manner: Since the diameter of the spaces, into which rays flowing from the several points of an object are collected, are as the breadth of the object-glass, it is evident that the degree of confusedness in the image is as the breadth of that glass; for the degree of confusedness will only be as the diameters or breadths of those spaces, and not as the spaces themselves. Now the focal length of the eye-glass, that is,

its power of magnifying, must be as that degree; for, if it exceeds it, it will render the confusedness sensible; and therefore it must be as the breadth or diameter of the object-glass. The diameter of the object-glass, which is as the square root of its aperture or magnitude, must be as the square-root of the power of magnifying in the telescope; for unless the aperture itself be as the power of magnifying, the image will want light: the square root of the power of magnifying will be as the square root of the focal distance of the object-glass; and therefore the focal distance of the eye-glass must be only as the square root of that of the object-glass. So that in making use of an object-glass of a longer focus, suppose, than one that is given, you are not obliged to apply an eye-glass of a proportionably longer focus than what would suit the given object-glass, but such an one only whose focal distance shall be to the focal distance of that which will suit the given object-glass, as the square root of the focal length of the object-glass you make use of, is to the square root of the focal length of the given one. And this is the reason that longer telescopes are capable of magnifying in a greater degree than shorter ones, without rendering the object confused or coloured.

3. But the inconveniency of very long telescopes is so great, that different attempts have been made to remove it. Of these, the most successful have been by Dollond and Blair; and the general principles upon which these eminent opticians proceeded have been mentioned in the historical part of this article, and in the preceding section. The public will soon be favoured with a fuller account of Dr Blair's discovery from his own pen; and of Dollond's, it may be sufficient to observe, in addition to what has been already said, that the object-glasses of his telescopes are composed of three distinct lenses, two convex and one concave; of which the concave one is placed in the middle, as is represented in fig. 3. where *a* and *c* show the two convex lenses, and *bb* the concave one, which is by the British artists placed in the middle. The two convex ones are made of London crown glass, and the middle one of white flint glass; and they are all ground to spheres of different radii, according to the refractive powers of the different kinds of glass and the intended focal distance of the object-glass of the telescope. According to Boscovich, the focal distance of the parallel rays for the concave lens is one-half, and for the convex glass one-third of the combined focus. When put together, they refract the rays in the following manner. Let *ab*, *ab* (fig. 4.), be two red rays of the sun's light falling parallel on the first convex lens *c*. Supposing there was no other lens present but that one, they would then be converged into the lines *be*, *be*, and at last meet in the focus *q*. Let the lines *gb*, *gb*, represent two violet rays falling on the surface of the lens. These are also refracted, and will meet in a focus; but as they have a greater degree of refrangibility than the red rays, they must of consequence converge more by the same power of refraction in the glass, and meet sooner in a focus, suppose at *r*.—Let now the concave lens *dd* be placed in such a manner as to intercept all the rays before they come to their focus. Were this lens made of the same materials, and ground to the same radius with the convex one, it would

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Their im-
perfections
remedied
by Dollond
and Blair.

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Refracting
telescopes
magnify in
proportion
to their
length.

Fig. 1.

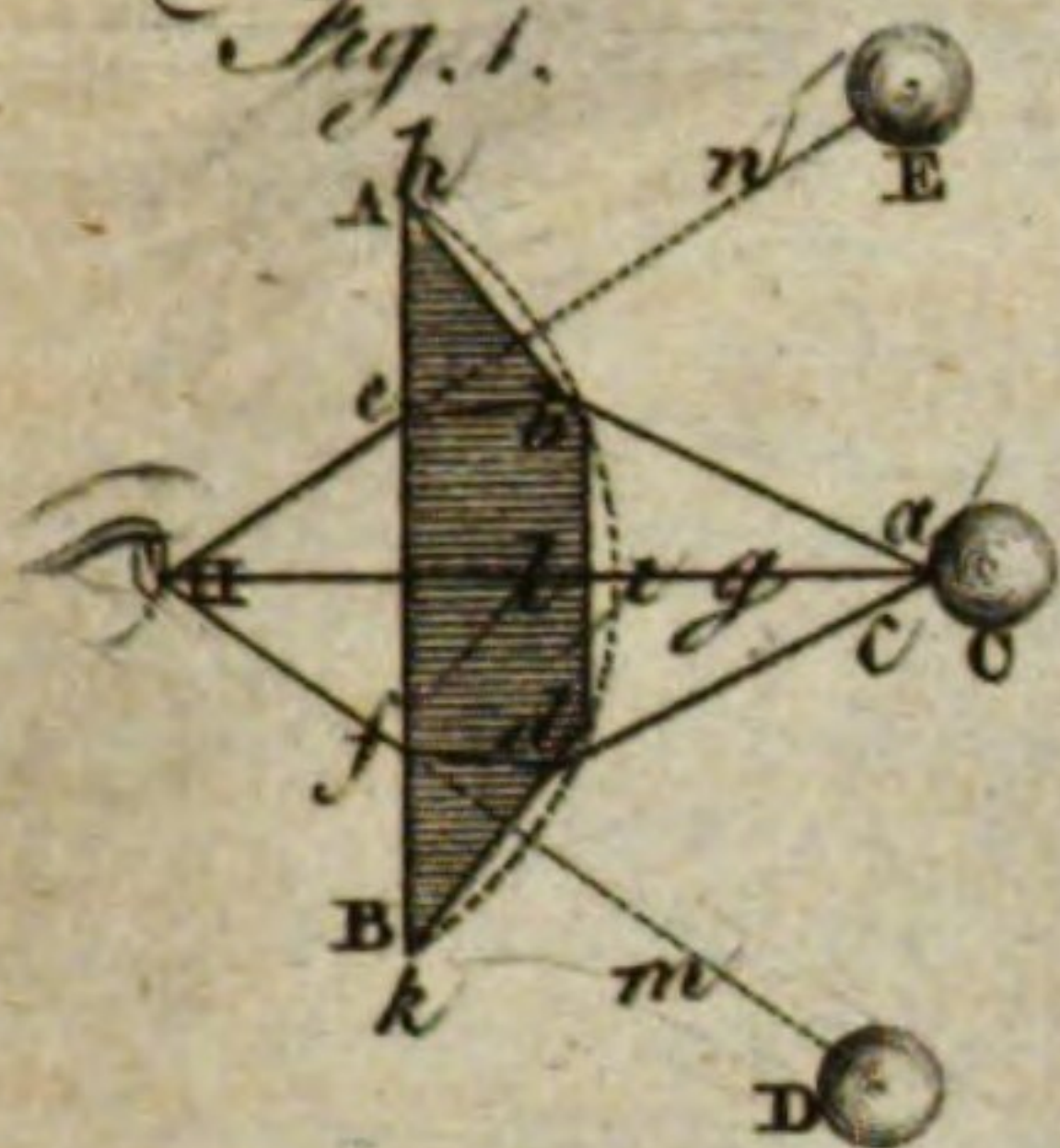


Fig. 2.

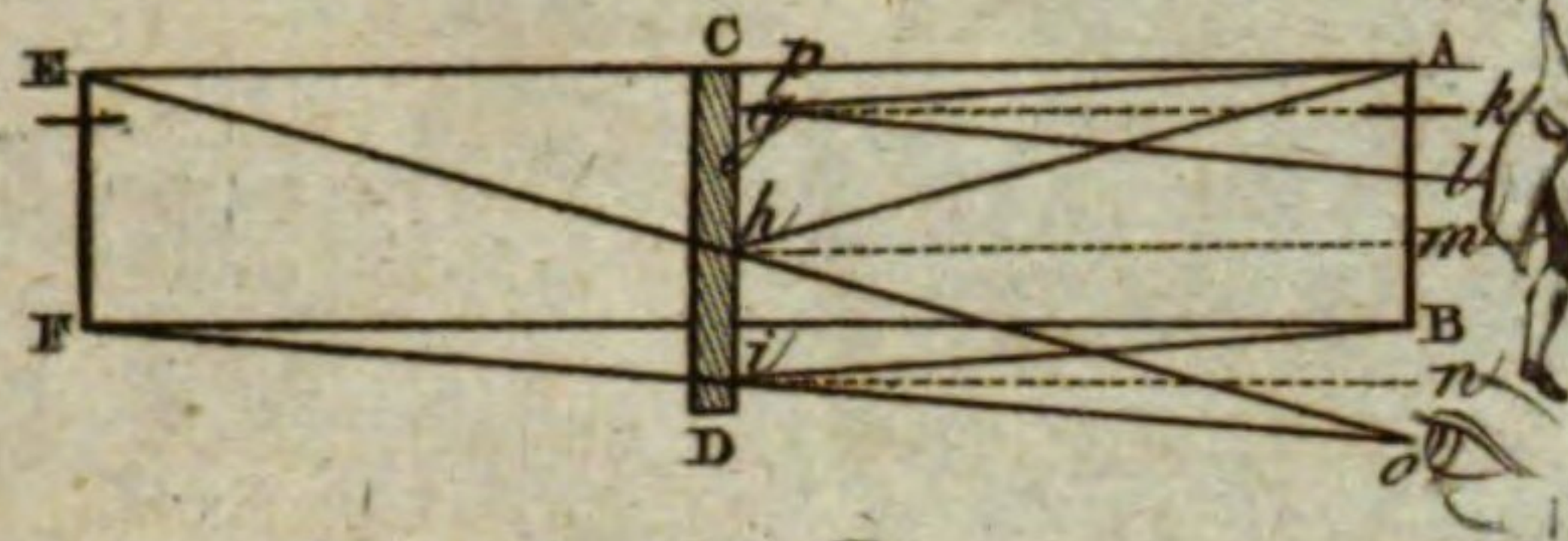


Fig. 3.

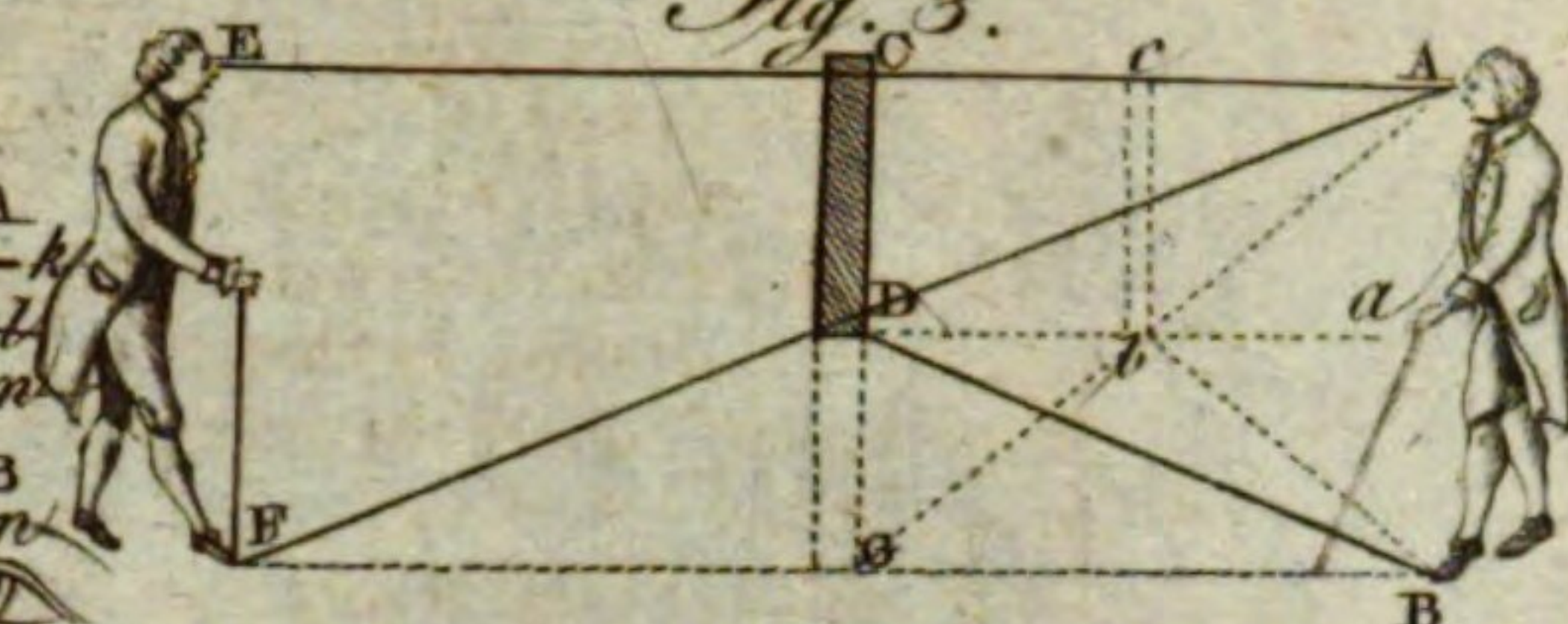


Fig. 4.

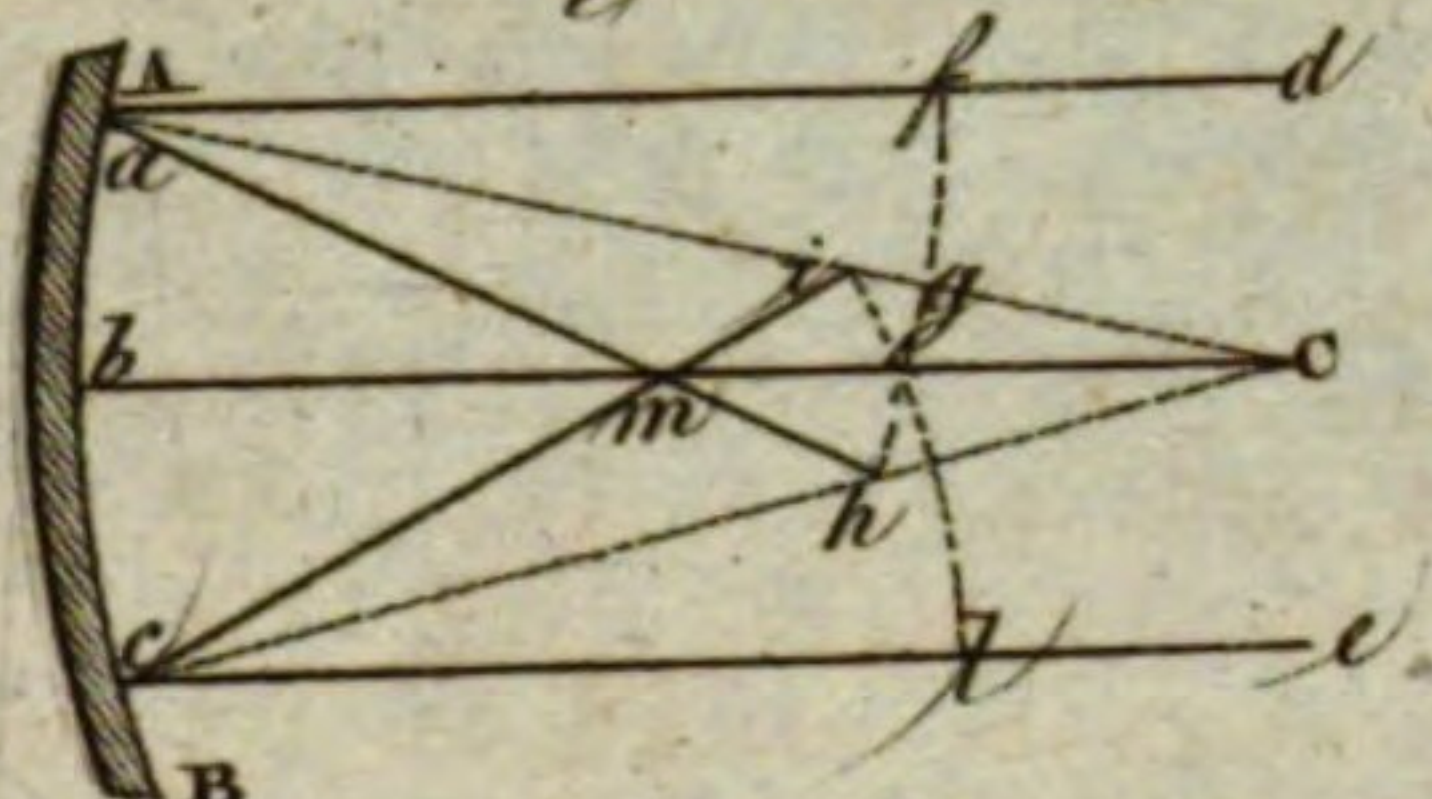


Fig. 5.

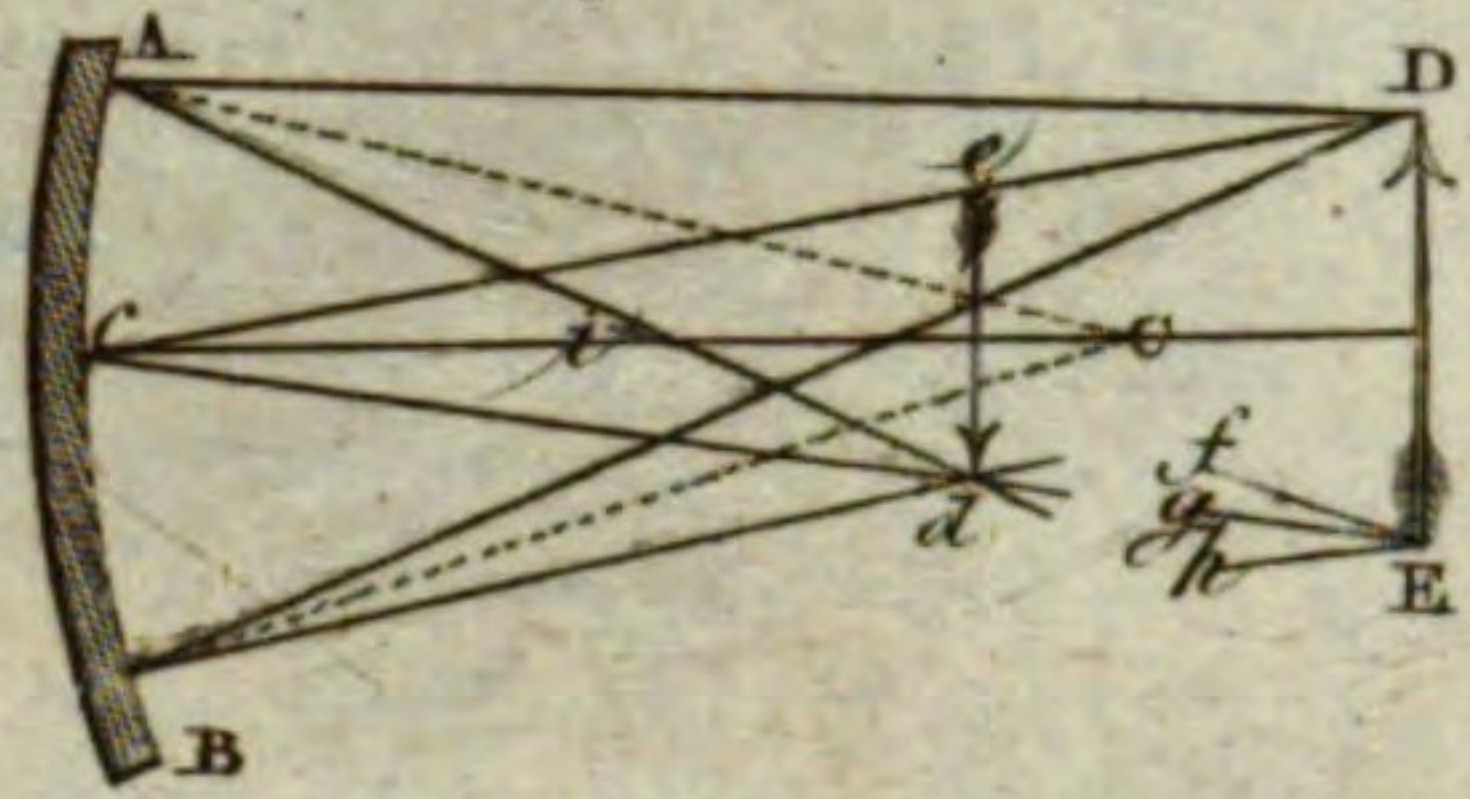


Fig. 6.

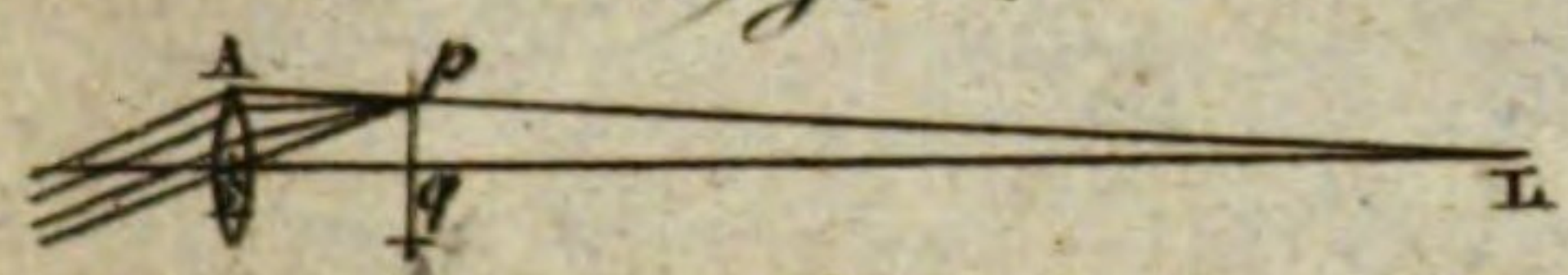


Fig. 7.

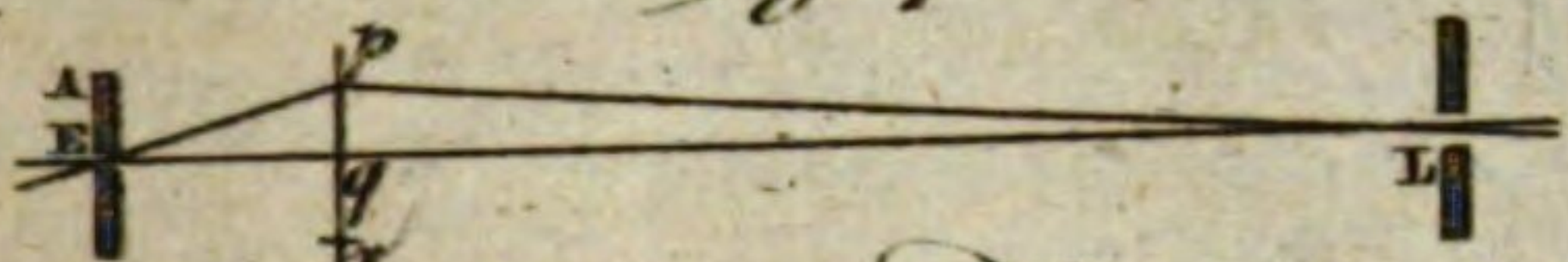


Fig. 10.

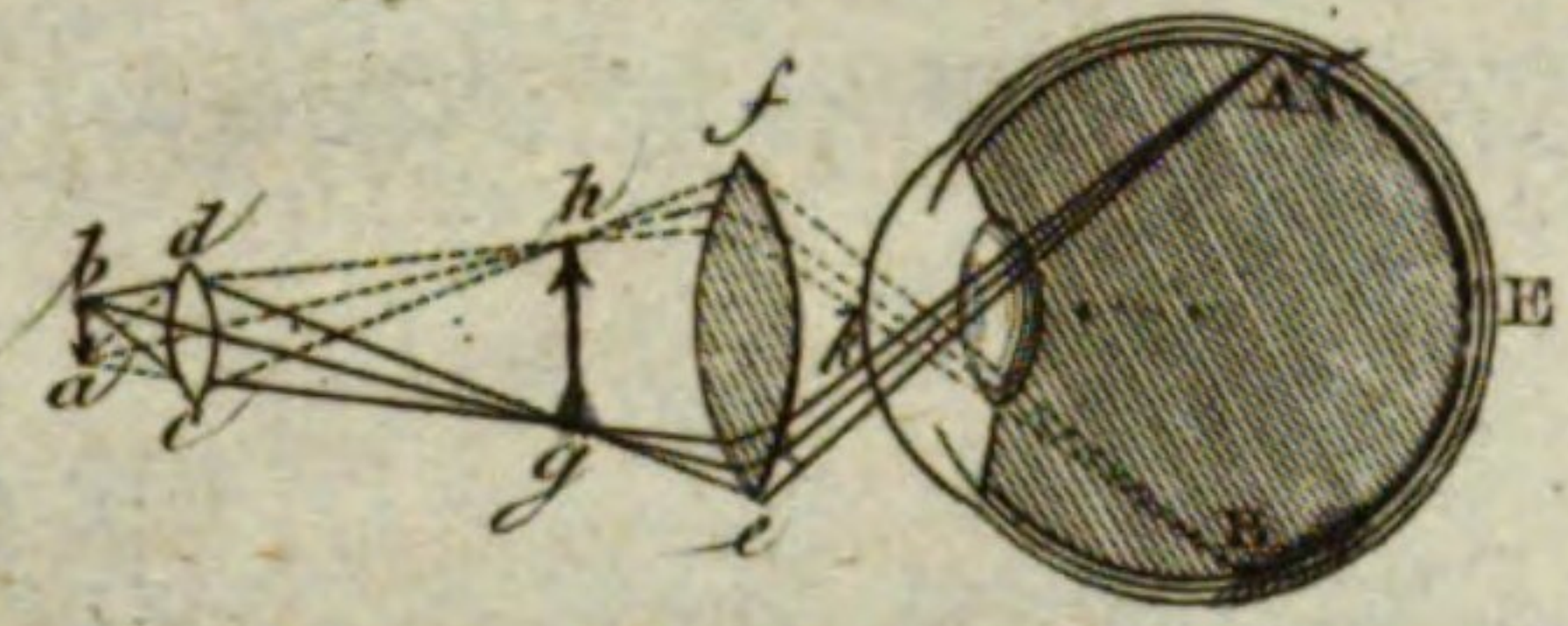
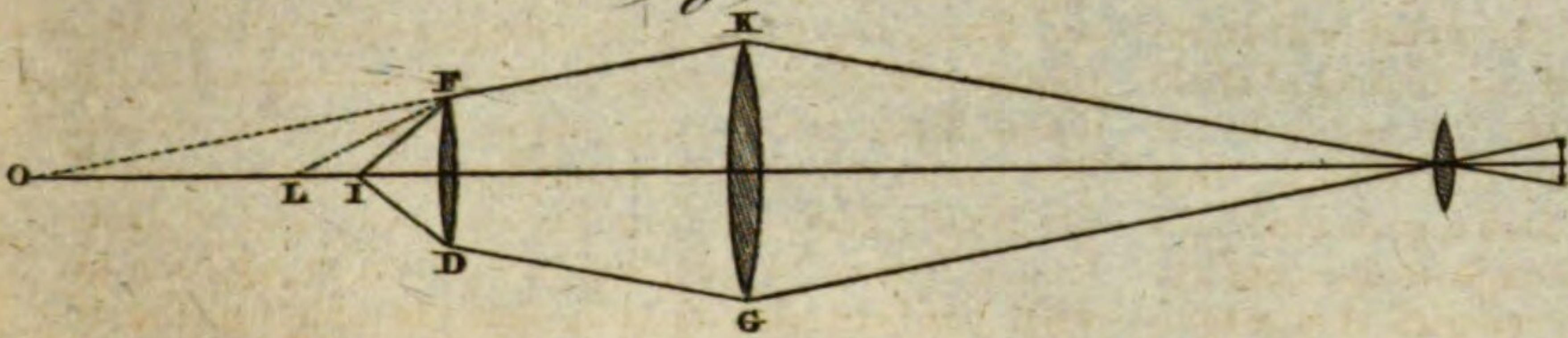


Fig. 8.

Fig. 9.

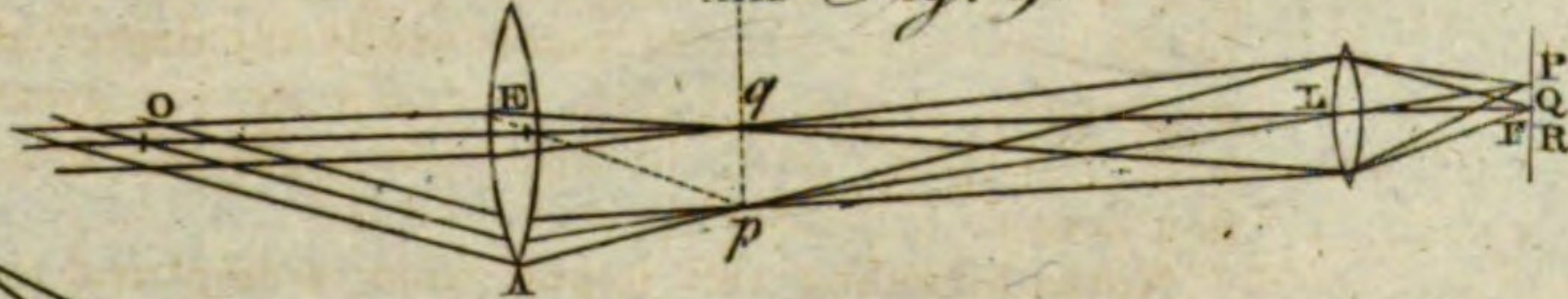


Fig. 11.

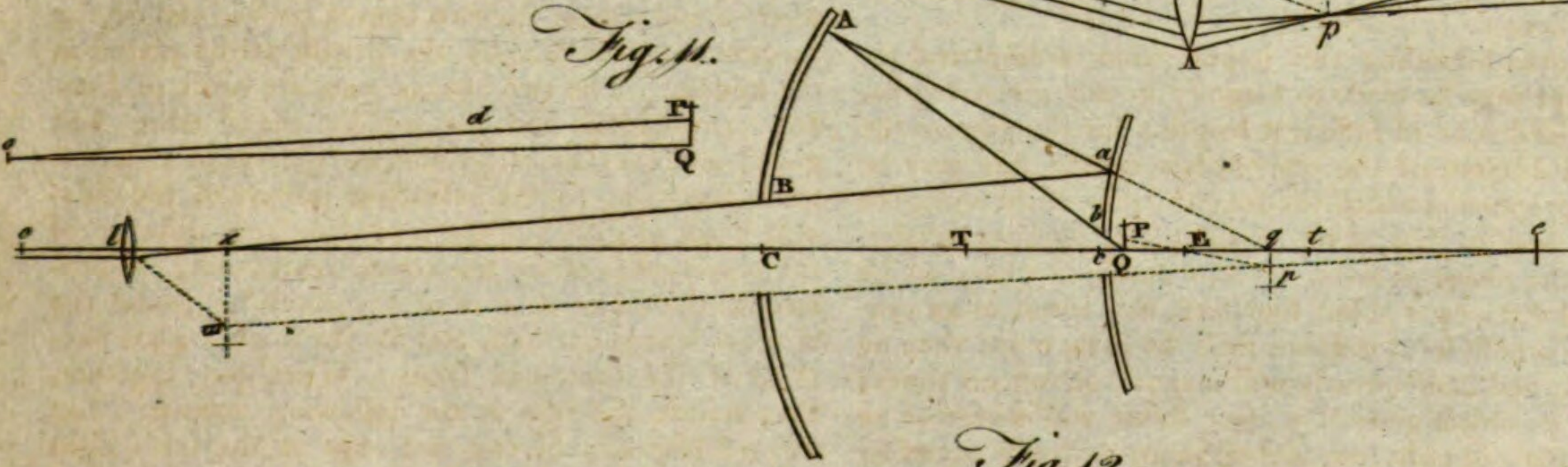


Fig. 12.

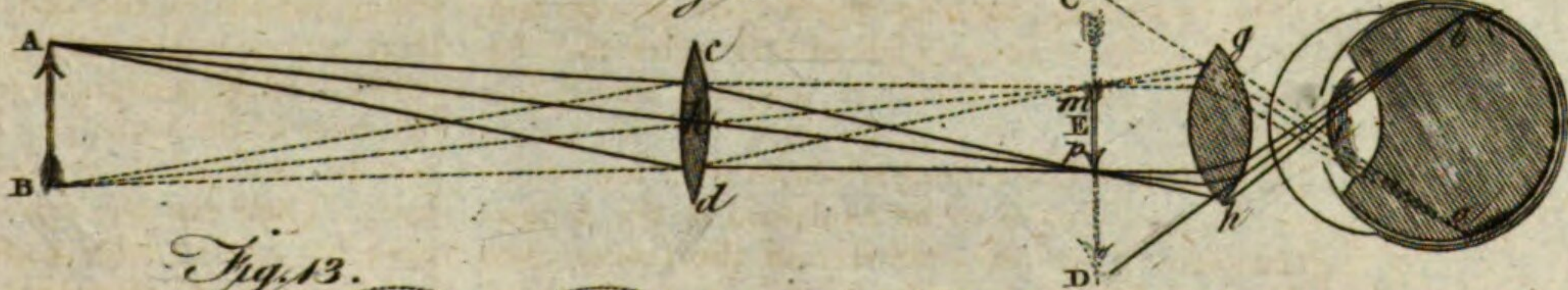
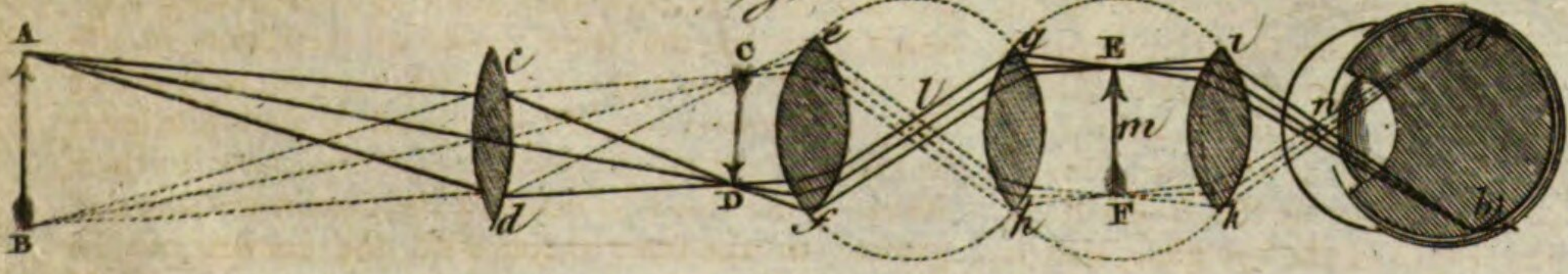


Fig. 13.



Refracting
TelescopeReflecting
Telescope.

would have the same power to cause the rays diverge that the former had to make them converge. In this case, the red rays would become parallel, and move on in the line oo, oo : But the concave lens, being made of flint glass, and upon a shorter radius, has a greater refractive power, and therefore they diverge a little after they come out of it; and if no third lens was interposed, they would proceed diverging in the lines opt, opt ; but, by the interposition of the third lens ovo , they are again made to converge, and meet in a focus somewhat more distant than the former, as at x . By the concave lens the violet rays are also refracted, and made to diverge: but having a greater degree of refrangibility, the same power of refraction makes them diverge somewhat more than the red ones; and thus, if no third lens was interposed, they would proceed in such lines as lmn, lmn . Now as the differently coloured rays fall upon the third lens with different degrees of divergence, it is plain, that the same power of refraction in that lens will operate upon them in such a manner as to bring them all together to a focus very nearly at the same point. The red rays, it is true, require the greatest power of refraction to bring them to a focus; but they fall upon the lens with the least degree of divergence. The violet rays, though they require the least power of refraction, yet have the greatest degree of divergence; and thus all meet together at the point x , or very nearly so.

But, though we have hitherto supposed the refraction of the concave lens to be greater than that of the convex ones, it is easy to see how the errors occasioned by the first lens may be corrected by it, though it should have even a less power of refraction than the convex one. Thus, let ab, ab (fig. 5.) be two rays of red light falling upon the convex lens c , and refracted into the focus q ; let also gb, gb be two violet rays converged into a focus at r ; it is not necessary, in order to their convergence into a common focus at x , that the concave lens should make them diverge: it is sufficient if the glass has a power of dispersing the violet rays somewhat more than the red ones; and many kinds of glass have this power of dispersing some kinds of rays, without a very great power of refraction. It is better, however, to have the object-glass composed of three lenses; because there is then another correction of the aberration by means of the third lens; and it might be impossible to find two lenses, the errors of which would exactly correct each other. It is also easy to see, that the effect may be the same whether the concave glass is a portion of the same sphere with the others or not; the effect depending upon a combination of certain circumstances, of which there is an infinite variety.

By means of this correction of the errors arising from the different refrangibility of the rays of light, it is possible to shorten dioptric telescopes considerably, and yet leave them equal magnifying powers. The reason of this is, that the errors arising from the object-glass being removed, those which are occasioned by the eye-glass are inconsiderable: for the error is always in proportion to the length of the focus in any glass; and in very long telescopes it becomes exceedingly great, being no less than $\frac{1}{8}$ th of the whole; but in glasses of a few inches focus it becomes trifling. Refracting telescopes, which go by the name of *Dol-*

lond's, are therefore now constructed in the following manner. Let AB (fig. 6.) represent an object-glass composed of three lenses as above described, and converging the rays 1, 2, 3, 4, &c. to a very distant focus as at x . By means of the interposed lens CD , however, they are converged to one much nearer, as at y , where an image of the object is formed. The rays diverging from thence fall upon another lens EF , where the pencils are rendered parallel, and an eye placed near that lens would see the object magnified and very distinct. To enlarge the magnifying power still more, however, the pencils thus become parallel are made to fall upon another at GH ; by which they are again made to converge to a distant focus: but, being intercepted by the lens IK , they are made to meet at the nearer one z ; whence diverging to LM , they are again rendered parallel, and the eye at N sees the object very distinctly.

From an inspection of the figure it is evident, that Dollond's telescope thus constructed is in fact two telescopes combined together; the first ending with the lens EF , and the second with LM . In the first we do not perceive the object itself, but the image of it formed at y ; and in the second we perceive only the image of that image formed at z . Nevertheless such telescopes are exceedingly distinct, and represent objects so clearly as to be preferred, in viewing terrestrial things, even to reflectors themselves. The latter indeed have greatly the advantage in their powers of magnifying, but they are much deficient in point of light. Much more light is lost by reflection than by refraction: and as in these telescopes the light must unavoidably suffer two reflections, a great deal of it is lost; nor is this loss counterbalanced by the greater aperture which these telescopes will bear, which enables them to receive a greater quantity of light than the refracting ones. The metals of reflecting telescopes also are very much subject to tarnish, and require much more dexterity to clean them than the glasses of refractors; which makes them more troublesome and expensive, though for making discoveries in the celestial regions they are undoubtedly the only proper instruments which have been hitherto constructed. If Dr Blair indeed shall be so fortunate as discover a vitreous substance of the same powers with the fluid in the compound object-glass of his telescope (and from his abilities and perseverance we have every thing to hope), a refracting telescope may be constructed superior for every purpose to the best reflector.

II. THE REFLECTING TELESCOPE.

THE inconveniences arising from the great length of refracting telescopes, before Dollond's discovery, are sufficiently obvious; and these, together with the difficulties occasioned by the different refrangibility of light, induced Sir Isaac Newton to turn his attention to the subject of reflection, and endeavour to realize the ideas of himself and others concerning the possibility of constructing telescopes upon that principle.—The instrument which he contrived is represented, fig. 7. where $ABCD$ is a large tube, open at AD and closed at BC , and of a length at least equal to the distance of the focus from the metallic spherical concave speculum GH placed at the end BC . The rays EG, FH , &c. proceeding from a remote object PR , intersect

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intersect one another somewhere before they enter the tube, so that EG, eg are those that come from the lower part of the object, and fb, FH from its upper part: these rays, after falling on the speculum GH , will be reflected, so as to converge and meet in mn , where they will form a perfect image of the object.— But as this image cannot be seen by the spectator, they are intercepted by a small plane metallic speculum KK , intersecting the axis at an angle of 45° , by which the rays tending to mn will be reflected towards a hole LL in the side of the tube, and the image of the object will thus be formed in qS ; which image will be less distinct, because some of the rays which would otherwise fall on the concave speculum GH , are intercepted by the plane speculum: nevertheless it will appear in a considerable degree distinct, because the aperture AD of the tube, and the speculum GH are large. In the lateral hole LL is fixed a convex lens, whose focus is at Sq ; and therefore this lens will refract the rays that proceed from any point of the image, so as at their exit they will be parallel, and those that proceed from the extreme points Sq will converge after refraction, and form an angle at O , where the eye is placed; which will see the image Sq , as if it were an object, through the lens LL ; consequently the object will appear enlarged, inverted, bright, and distinct. In LL lenses of different convexities may be placed, which by being moved nearer to the image or farther from it, would represent the object more or less magnified, provided that the surface of the speculum GH be of a perfectly spherical figure. If, in the room of one lens LL , three lenses be disposed in the same manner with the three eye-glasses of the refracting telescope, the object will appear erect, but less distinct than when it is observed with one lens. On account of the position of the eye in this telescope, it is extremely difficult to direct the instrument towards any object. Huygens, therefore, first thought of adding to it a small refracting telescope, the axis of which is parallel to that of the reflector. This is called a *finder*, or *director*. The Newtonian telescope is also furnished with a suitable apparatus for the commodious use of it.

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In order to determine the magnifying power of this telescope, it is to be considered that the plane speculum KK is of no use in this respect. Let us then suppose, that one ray proceeding from the object coincides with the axis GLA (fig. 8.) of the lens and speculum; let bb be another ray proceeding from the lower extreme of the object, and passing through the focus I of the speculum KH : this will be reflected in the direction $b i d$, parallel to the axis GLA , and falling on the lens $d L d$, will be refracted to G ; so that GL will be equal to LI , and $d G = d I$. To the naked eye the object would appear under the angle $I b i = b I A$; but by means of the telescope it appears under the angle $d G L = d I L = I d i$: and the angle $I d i$ is to the angle $I b i :: b I : I d$; consequently the apparent magnitude by the telescope is to that by the naked eye as the distance of the focus of the speculum from the speculum, to the distance of the focus of the lens from the lens.

The Newtonian telescope was still inconvenient. Notwithstanding the contrivance of Huygens, objects were by it found with difficulty. The telescope of

Gregory, therefore, soon obtained the preference, to which for most purposes it is justly intitled, as the reader will perceive from the following construction.

Let $TYYT$ (fig. 9.) be a brass tube, in which L/dD is a metallic concave speculum, perforated in the middle at X ; and EF a less concave mirror, so fixed by the arm or strong wire RT , which is moveable by means of a long screw on the outside of the tube, as to be moved nearer to or farther from the larger speculum L/dD , its axis being kept in the same line with that of the great one. Let AB represent a very remote object, from each part of which issue pencils of rays, e. g. cd, CD , from A the upper extreme of the object, and IL, il , from the lower part B ; the rays IL, CD from the extremes crossing one another before they enter the tube. These rays, falling upon the larger mirror LD , are reflected from it into the focus KH , where they form an inverted image of the object AB , as in the Newtonian telescope. From this image the rays, issuing as from an object, fall upon the small mirror EF , the centre of which is at e ; so that after reflection they would meet in their foci at QQ , and there form an erect image. But since an eye at that place could see but a small part of an object, in order to bring rays from more distant parts of it into the pupil, they are intercepted by the plano-convex lens MN , by which means a smaller erect image is formed at PV , which is viewed through the meniscus SS by an eye at O . This meniscus both makes the rays of each pencil parallel, and magnifies the image PV . At the place of this image all the foreign rays are intercepted by the perforated partition ZZ . For the same reason the hole near the eye O is very narrow. When nearer objects are viewed by this telescope, the small speculum EF is removed to a greater distance from the larger LD , so that the second image may be always formed in PV ; and this distance is to be adjusted (by means of the screw on the outside of the great tube) according to the form of the eye of the spectator. It is also necessary, that the axis of the telescope should pass through the middle of the speculum EF , and its centre, the centre of the speculum LL , and the middle of the hole X , the centres of the lenses MN, SS , and the hole near O . As the hole X in the speculum LL can reflect none of the rays issuing from the object, that part of the image which corresponds to the middle of the object must appear to the observer more dark and confused than the extreme parts of it. Besides, the speculum EF will also intercept many rays proceeding from the object; and therefore, unless the aperture TT be large, the object must appear in some degree obscure.

In the best reflecting telescopes, the focus of the small mirror is never coincident with the focus of the great one, where the first image KH is formed, but a little beyond it (with respect to the eye), as at n ; the consequence of which is, that the rays of the pencils will not be parallel after reflection from the small mirror, but converge so as to meet in points about QqQ , where they would form a larger upright image than PV , if the glass R was not in their way; and this image might be viewed by means of a single eye-glass properly placed between the image and the eye: but then the field of view would be less, and consequently

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Fig. 1.

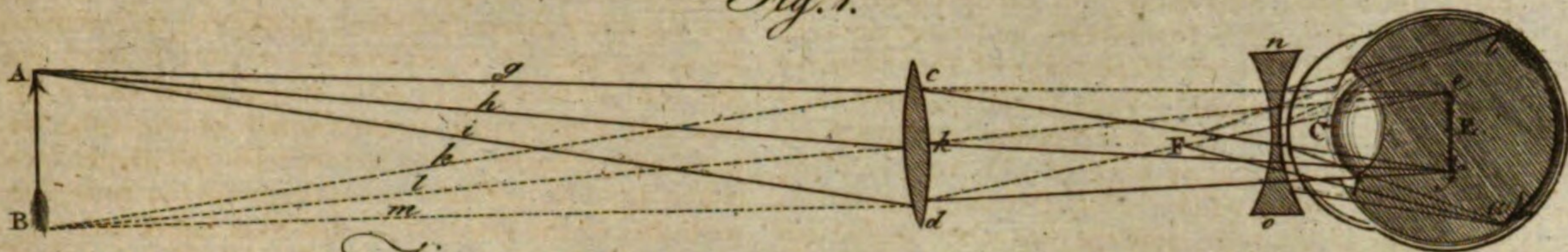


Fig. 2.

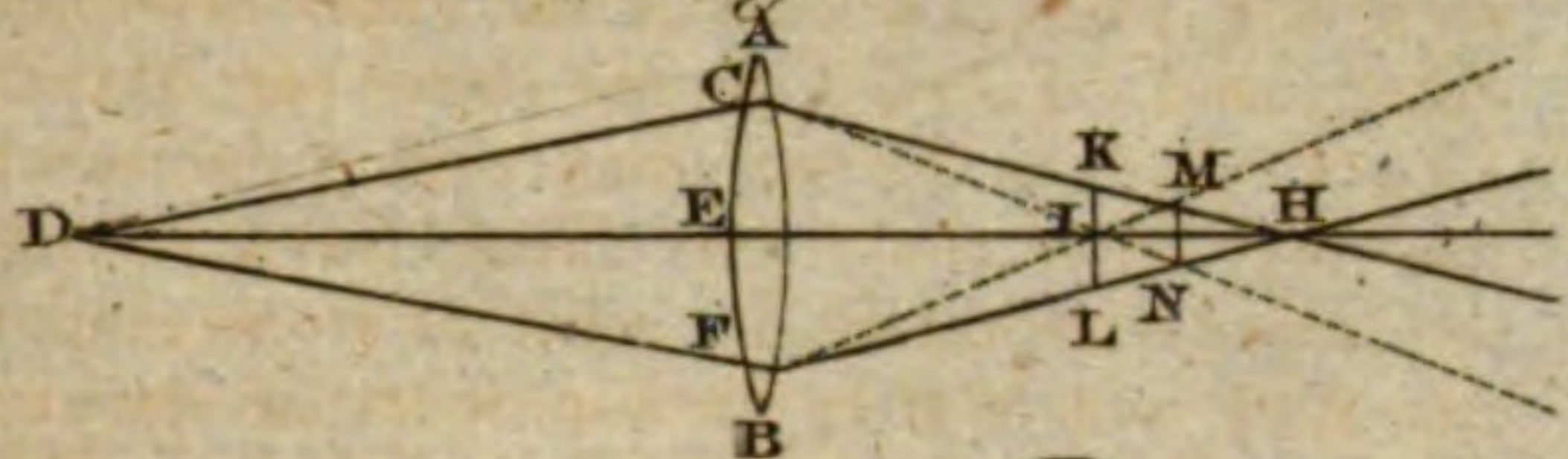


Fig. 3.

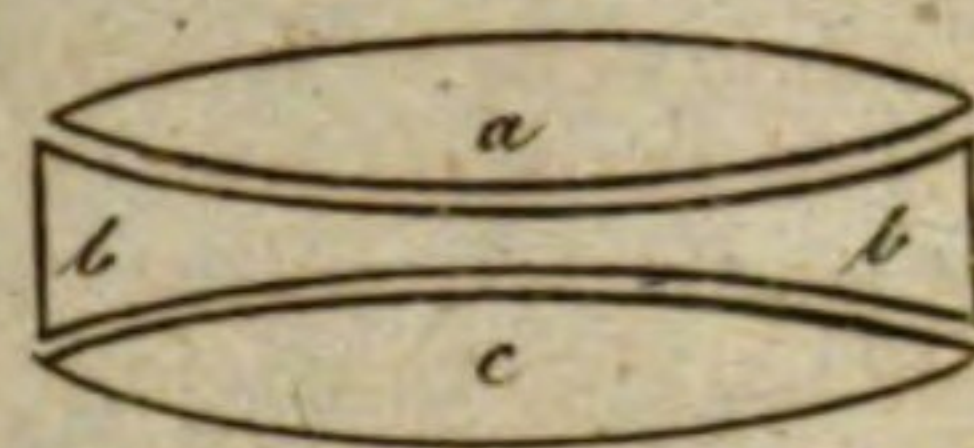


Fig. 4.

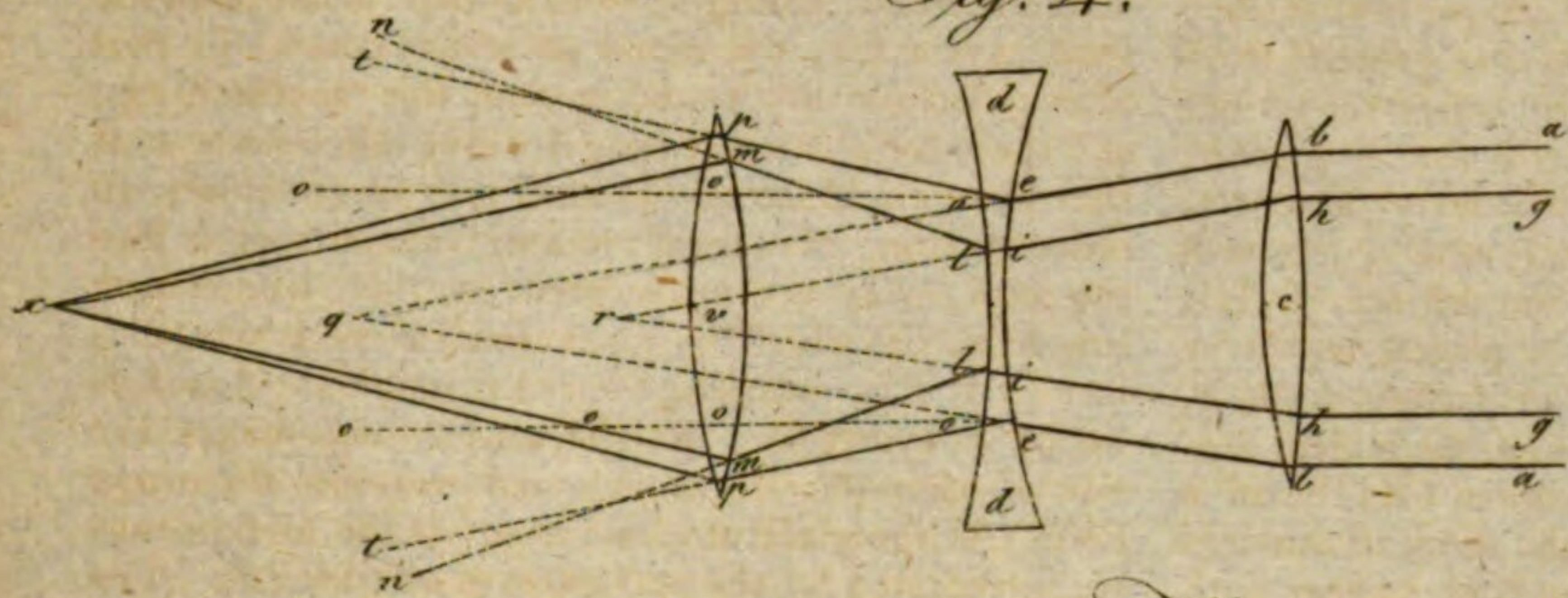


Fig. 8.



Fig. 5.

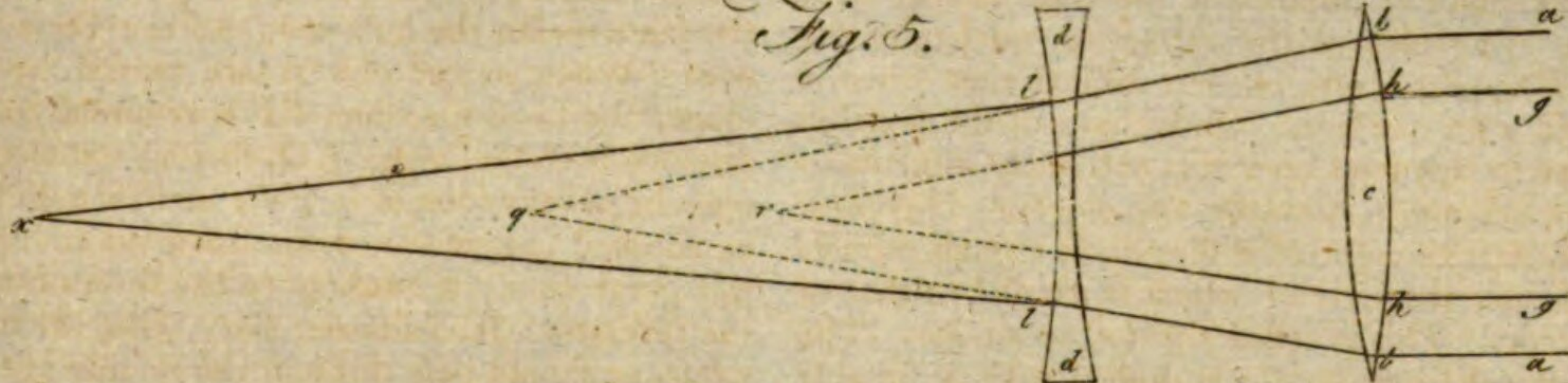


Fig. 6.

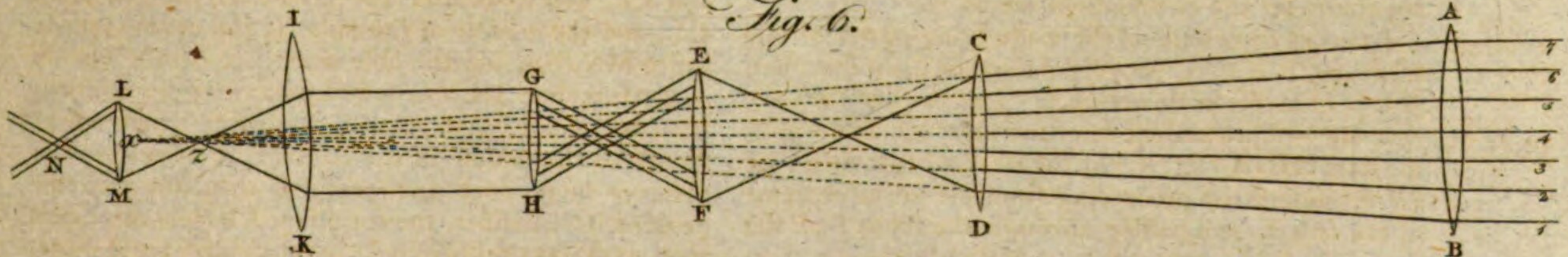


Fig. 7.

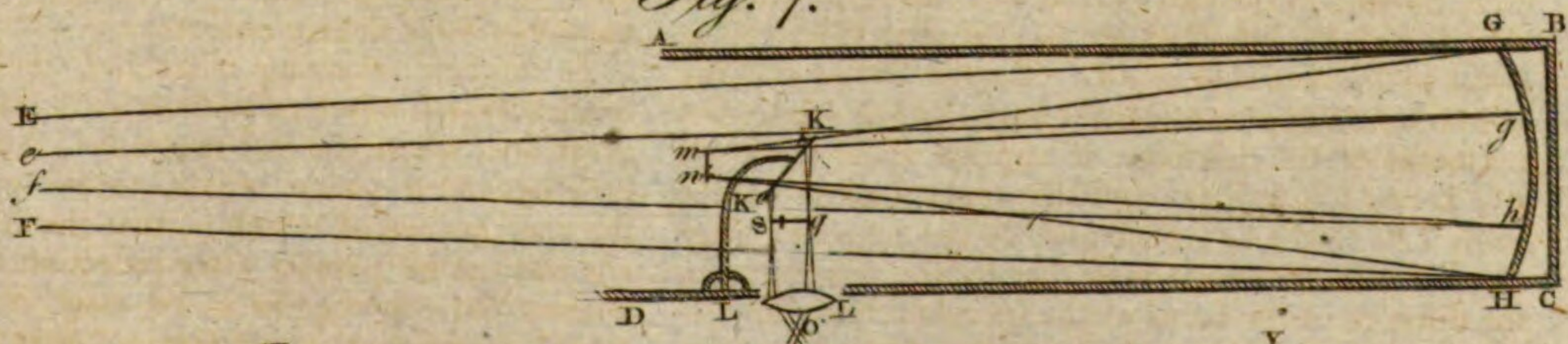
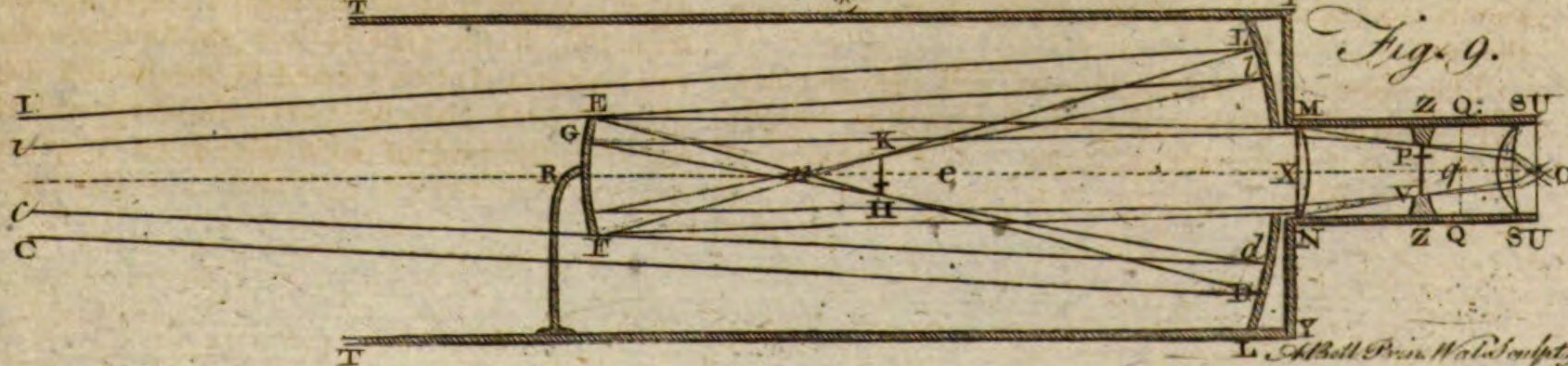


Fig. 9.



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quently not so pleasant; for which reason, the glass R is still retained, to enlarge the scope or area of the field.

To find the magnifying power of this telescope, multiply the focal distance of the great mirror by the distance of the small mirror from the image next the eye, and multiply the focal distance of the small mirror by the focal distance of the eye-glass: then divide the product of the former multiplication by the product of the latter, and the quotient will express the magnifying power.

One great advantage of the reflecting telescope is, that it will admit of an eye-glass of a much shorter focal distance than a refracting telescope will; and consequently it will magnify so much the more: for the rays are not coloured by reflection from a concave mirror, if it be ground to a true figure, as they are by passing through a convex glass, let it be ground ever so true.

The nearer an object is to the telescope, the more its pencils of rays will diverge before they fall upon the great mirror, and therefore they will be the longer of meeting in points after reflection; so that the first image KH will be formed at a greater distance from the large mirror, when the object is near the telescope, than when it is very remote. But as this image must be formed farther from the small mirror than its principal focus n , this mirror must be always set at a greater distance from the large one, in viewing near objects, than in viewing remote ones. And this is done by turning the screw on the outside of the tube, until the small mirror be so adjusted, that the object (or rather its image) appears perfect.

In looking through any telescope towards an object, we never see the object itself, but only that image of it which is formed next the eye in the telescope. For if a man holds his finger or a stick between his bare eye and an object, it will hide part (if not the whole) of the object from his view: But if he ties a stick across the mouth of a telescope before the object-glass, it will hide no part of the imaginary object he saw through the telescope before, unless it covers the whole mouth of the tube: for all the effect will be, to make the object appear dimmer, because it intercepts part of the rays. Whereas, if he puts only a piece of wire across the inside of the tube, between the eye-glass and his eye, it will hide part of the object which he thinks he sees; which proves, that he sees not the real object, but its image. This is also confirmed by means of the small mirror EF, in the reflecting telescope, which is made of opaque metal, and stands directly between the eye and the object towards which the telescope is turned; and will hide the whole object from the eye at O, if the two glasses ZZ and SS are taken out of the tube.

Great improvements have been lately made in the construction of both reflecting and refracting telescopes, as well as in the method of applying those instruments to the purposes for which they are intended. These, however, fall not properly under the science of optics, as fitter opportunities occur of giving a full account of them, as well as of the magic lantern, camera obscura, &c. under other articles of our multifarious work. See CATOPTICS, DIOPTRICS, SPECULUM,

and TELESCOPE. We shall conclude this article with some observations

On the different Merits of Microscopes and Telescopes, compared with one another; how far we may reasonably depend on the Discoveries made by them, and what hopes we may entertain of further Improvements.

THE advantages arising from the use of microscopes and telescopes depend, in the first place, upon their property of magnifying the minute parts of objects, so that they can by that means be more distinctly viewed by the eye; and, secondly, upon their throwing more light into the pupil of the eye than what is done without them. The advantages arising from the magnifying power would be extremely limited, if they were not also accompanied by the latter: for if the same quantity of light is spread over a large portion of surface, it becomes proportionably diminished in force; and therefore the objects, though magnified, appear proportionably dim. Thus, though any magnifying glass should enlarge the diameter of the object 10 times, and consequently magnify the surface 100 times, yet if the focal distance of the glass was about eight inches (provided this was possible), and its diameter only about the size of the pupil of the eye, the object would appear 100 times more dim when we looked through the glass, than when we beheld it with our naked eyes; and this, even on a supposition that the glass transmitted all the light which fell upon it, which no glass can do. But if the focal distance of the glass was only four inches, though its diameter remained as before, the inconvenience would be vastly diminished, because the glass could then be placed twice as near the object as before, and consequently would receive four times as many rays as in the former case, and therefore we would see it much brighter than before. Going on thus, still diminishing the focal distance of the glass, and keeping its diameter as large as possible, we will perceive the object more and more magnified, and at the same time very distinct and bright. It is evident, however, that with regard to optical instruments of the microscopic kind, we must sooner or later arrive at a limit which cannot be passed. This limit is formed by the following particulars. 1. The quantity of light lost in passing through the glass. 2. The diminution of the glass itself, by which it receives only a small quantity of rays. 3. The extreme shortness of the focal distance of great magnifiers, whereby the free access of the light to the object which we wish to view is impeded, and consequently the reflection of the light from it is weakened. 4. The aberrations of the rays, occasioned by their different refrangibility.

To understand this more fully, as well as to see how far these obstacles can be removed, let us suppose the lens made of such a dull kind of glass that it transmits only one half of the light which falls upon it. It is evident that such a glass, of four inches focal distance, and which magnifies the diameter of an object twice, still supposing its own breadth equal to that of the pupil of the eye, will show it four times magnified in surface, but only half as bright as if it was seen by the naked eye at the usual distance; for the light which falls upon the eye from the object at eight inches distance, and likewise the surface of the object in its natural

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natural size, being both represented by 1, the surface of the magnified object will be 4, and the light which makes that magnified object visible only 2; because though the glass receives four times as much light as the naked eye does at the usual distance of distinct vision, yet one half is lost in passing through the glass. The inconvenience in this respect can therefore be removed only as far as it is possible to increase the clearness of the glass, so that it shall transmit nearly all the rays which fall upon it; and how far this can be done, hath not yet been ascertained.

The second obstacle to the perfection of microscopic glasses is the small size of great magnifiers, by which, notwithstanding their near approach to the object, they receive a smaller quantity of rays than might be expected. Thus, suppose a glass of only $\frac{1}{10}$ th of an inch focal distance; such a glass would increase the visible diameter 80 times, and the surface 6400 times. If the breadth of the glass could at the same time be preserved as great as that of the pupil of the eye, which we shall suppose $\frac{3}{8}$ ths of an inch, the object would appear magnified 6400 times, at the same time that every part of it would be as bright as it appears to the naked eye. But if we suppose that this magnifying glass is only $\frac{1}{8}$ th of an inch in diameter, it will then only receive $\frac{1}{4}$ th of the light which otherwise would have fallen upon it; and therefore, instead of communicating to the magnified object a quantity of illumination equal to 6400, it would communicate only one equal to 1600, and the magnified object would appear four times as dim as it does to the naked eye. This inconvenience, however, is still capable of being removed, not indeed by increasing the diameter of the lens, because this must be in proportion to its focal distance, but by throwing a greater quantity of light on the object. Thus, in the above-mentioned example, if four times the quantity of light which naturally falls upon it could be thrown upon the object, it is plain that the reflection from it would be four times as great as in the natural way; and consequently the magnified image, at the same time that it was as many times magnified as before, would be as bright as when seen by the naked eye. In transparent objects this can be done very effectually by a concave speculum, as in the reflecting microscope already described: but in opaque objects the case is somewhat more doubtful; neither do the contrivances for viewing these objects seem entirely to make up for the deficiencies of the light from the smallness of the lens and shortness of the focus.—When a microscopic lens magnifies the diameter of an object 40 times, it hath then the utmost possible magnifying power, without diminishing the natural brightness of the object.

The third obstacle arises from the shortness of the focal distance in large magnifiers: but in transparent objects, where a sufficient quantity of light is thrown on the object from below, the inconvenience arises at last from straining the eye, which must be placed nearer the glass than it can well bear; and this entirely supercedes the use of magnifiers beyond a certain degree.

The fourth obstacle arises from the different refrangibility of the rays of light, and which frequently causes such a deviation from truth in the appearances of things, that many people have imagined themselves to have

made surprising discoveries, and have even published them to the world; when in fact they have been only as many optical deceptions, owing to the unequal refractions of the rays. For this there seems to be no remedy, except the introduction of achromatic glasses into microscopes as well as telescopes. How far this is practicable, hath not yet been tried; but when these glasses shall be introduced (if such introduction is practicable), microscopes will then undoubtedly have received their ultimate degree of perfection.

With regard to telescopes, those of the refracting kind have evidently the advantage of all others, where the aperture is equal, and the aberrations of the rays are corrected according to Mr Dollond's method; because the image is not only more perfect, but a much greater quantity of light is transmitted than what can be reflected from the best materials hitherto known. Unluckily, however, the imperfections of the glass set a limit to these telescopes, as hath already been observed, so that they cannot be made above three feet and an half long. On the whole, therefore, the reflecting telescopes are preferable in this respect, that they may be made of dimensions greatly superior; by which means they can both magnify to a greater degree, and at the same time throw much more light into the eye.

With regard to the powers of telescopes, however, they are all of them exceedingly less than what we would be apt to imagine from the number of times which they magnify the object. Thus, when we hear of a telescope which magnifies 200 times, we are apt to imagine, that, on looking at any distant object through it, we should perceive it as distinctly as we would with our naked eye at the 200th part of the distance. But this is by no means the case; neither is there any theory capable of directing us in this matter: we must therefore depend entirely on experience.

The best method of trying the goodness of any telescope is by observing how much farther off you are able to read with it than you can with the naked eye. But that all deception may be avoided, it is proper to choose something to be read where the imagination cannot give any assistance, such as a table of logarithms, or something which consists entirely of figures; and hence the truly useful power of the telescope is easily known. In this way Mr Short's large telescope, which magnifies the diameter of objects 1200 times, is yet unable to afford sufficient light for reading at more than 200 times the distance at which we can read with our naked eye.

With regard to the form of reflecting telescopes, it is now pretty generally agreed, that when the Gregorian ones are well constructed, they have the advantage of those of the Newtonian form. One advantage evident at first sight is, that with the Gregorian telescope an object is perceived by looking directly through it, and consequently is found with much greater ease than in the Newtonian telescope, where we must look into the side. The unavoidable imperfection of the specula common to both, also gives the Gregorian an advantage over the Newtonian form. Notwithstanding the utmost care and labour of the workmen, it is found impossible to give the metals either a perfectly spherical or a perfectly parabolical form. Hence arises some

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some indistinctness of the image formed by the great speculum, which is frequently corrected by the little one, provided they are properly matched. But if this is not done, the error will be made much worse; and hence many of the Gregorian telescopes are far inferior to the Newtonian ones; namely, when the specula have not been properly adapted to each other. There is no method by which the workman can know the specula which will fit one another without a trial; and therefore there is a necessity for having many specula ready made of each sort, that in fitting up a telescope those may be chosen which best suit each other.

The brightness of any object seen through a telescope, in comparison with its brightness when seen by the naked eye, may in all cases be easily found by the following formula. Let n represent the natural distance of a visible object, at which it can be distinctly seen; and let d represent its distance from the object-glass of the instrument. Let m be the magnifying power of the instrument; that is, let the visual angle subtended at the eye by the object when at the distance n , and viewed without the instrument, be to the

visual angle produced by the instrument as 1 to m . Let a be the diameter of the object-glass, and p be that of the pupil. Let the instrument be so constructed, that no parts of the pencils are intercepted for want of sufficient apertures of the intermediate glasses. Lastly, let the light lost in reflection or refraction be neglected.

The brightness of vision through the instrument will be expressed by the fraction $\frac{a^2 n^2}{m p d^2}$, the brightness of natural vision being 1. But although this fraction may exceed unity, the vision through the instrument will not be brighter than natural vision. For, when this is the case, the pupil does not receive all the light transmitted through the instrument.

In microscopes, n is the nearest limits of distinct vision, nearly 8 inches. But a difference in this circumstance, arising from a difference in the eye, makes no change in the formula, because m changes in the same proportion with n .

In telescopes, n and d may be accounted equal, and the formula becomes $\frac{a^2}{m p^2}$.

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O P T

Optimates,
Optio.

OPTIMATES, one of the divisions of the Roman people opposed to *populares*. It is not easy to ascertain the characteristic differences betwixt these two parties. Some say the optimates were warm supporters of the dignity of the chief magistrate, and promoters of the grandeur of the state, who cared not if the inferior members suffered, provided the commanding powers were advanced: Whereas the *populares* boldly stood up for the rights of the people, pleaded for larger privileges, and laboured to bring matters nearer to a level. In short, they resembled, according to this account, the court and country parties amongst the people of this island.

Tully says, that the optimates were the best citizens, who wished to deserve the approbation of the better sort; and that the *populares* courted the favour of the populace, not so much considering what was right, as what would please the people and gratify their own thirst of vain glory and empty applause.

OPTIO, an officer in the Roman army, being an assistant or lieutenant to every centurion. The *optio* was so called because he was the choice or option of the centurion in later times; at first, however, he had been chosen by the tribune, or chief commander of the legion. These *optiones* are also sometimes called *succenturiones* and *tergiductores*; the last name was given them because their post was in the rear of the company. Some authors make mention of *sub-optiones* or sub-lieutenants.

O P U

It is proper however to add, that *optiones* were not peculiar to the camp, but were also used in a variety of other offices of life. Option,
Opuntia.

OPTION, the power or faculty of wishing, or choosing; or the choice a person makes of any thing.

When a new suffragan bishop is consecrated, the archbishop of the province, by a customary prerogative, claims the collation of the first vacant benefice, or dignity, in that see, according as he shall choose; which choice is called the archbishop's *option*.

But in case the bishop dies, or is translated, before the present incumbent of the promotion chosen by the archbishop shall die or be removed, it is generally supposed that the option is void; inasmuch as the granter, singly and by himself, could not convey any right or title beyond the term of his continuance in that see. And if the archbishop dies before the avoidance shall happen, the right of filling up the vacancy shall go to his executors or administrators.

OPUNTIA, a species of cactus; see CACTUS. The fruit of the opuntia is remarkable for colouring the juices of living animals, though it appears not to be poisonous or even hurtful to the body. In a letter from Charlestown in South Carolina, which was published in the 50th volume of the Philosophical Transactions, the author writes thus:—"As you desired, I tried the effects of the prickly pear in clearing the urine. A few days after your letter, I went down to one of the islands, and gathered some of the fruit, and

Or
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Oracle.

and gave four of the pears to a child of three years of age, and six pears to one of five. The next morning I examined the urine of both, and it appeared of a very lively red colour, as if tart-wine had been mixed with water. I gave likewise six pears to a negro-wench, who was suckling an infant, and strictly forbade her to put the child to her breast for six or eight hours; and then taking some of her milk in a tea-cup, and setting it by for some hours, the cream had a reddish lustre, though it was very faint." From the same letter we learn, that the prickly pear grows in great abundance about Carolina; and also that the cochineal insects are found upon it, though no attempt, that we know of, has hitherto been made to cure them for use as the Spaniards do.

OR, the French word for gold, by which this metal is expressed in heraldry. In engraving it is denoted by small points all over the field or bearing. It may be supposed to signify of itself, *generosity, splendour, or solidity*; according to G. Leigh, if it is compounded with

Gul.	} it signifies	Courage.
Azu.		Trust.
Vor.		Joy.
Pur.		Charity.
Sab.		Constancy.

ORA, in antiquity, was a term equivalent to an ounce; but it has been much debated among our antiquaries, whether the ora, the mention of which so often occurs, was a coin, or only money of account. Dr Hickes observes, that the mode of reckoning money by marks and oras was never known in England till after the Danish settlements; and by examining the old nummular estimates among the principal Gothic states upon the Baltic, it appears, that the ora and solidus were synonymous terms, and that the ora was the eighth part of the mark. From several of the Danish laws, it likewise appears, that the Danish ora, derived by corruption from *aureus*, was the same as the Frank solidus of twelve pence. As a weight, the ora was regarded as the uncia or unit, by which the Danish mark was divided; and in Doomsday-book the ora is used for the ounce, or the twelfth part of the nummular Saxon pound, and the fifteenth of the commercial; as a coin, it was an aureus, or the Frank solidus of twelve pence. And from the accidental coincidence of the Frank aureus with the eighth part of their mark, the Danes probably took occasion to give it the new name of *ora*. There was another ora mentioned in the rolls of the 27th of Henry III. the value of which was sixteen pence; and this was probably derived from the half mancus of the Saxons. Such, in all appearance, was the original of these two oras; as there were no aurei of that period, to which these two denominations of money of sixteen and twelve pence can possibly be ascribed. It is observed farther, that the name *ora* distinguishes the gold coins in several parts of Europe to this day. The Portuguese moidore is nothing else but *moeda d'oro*, from the Latin *moneta de auro*; the French *Louis d'ores* come from the same use of the word, and owe their appellation to the ora. See Clarke on Coins.

ORACH. See ATRIPLEX.

Wild ORACH. See CHENOPODIUM.

ORACLE, among the heathens, was the answer

which the gods were supposed to give to those who consulted them upon any affair of importance. It is also used for the god who was thought to give the answer, and for the place where it was given.

Oracle.

The credit of oracles was so great, that in all doubts and disputes their determinations were held sacred and inviolable: whence vast numbers flocked to them for advice about the management of their affairs; and no business of any consequence was undertaken, scarce any peace concluded, any war waged, or any new form of government instituted, without the advice and approbation of some oracle. The answers were usually given by the intervention of the priest or priestess of the god who was consulted; and generally expressed in such dark and unintelligible phrases, as might be easily wrested to prove the truth of the oracle whatever was the event. It is not, therefore, to be wondered at, that the priests who delivered them were in the highest credit and esteem, and that they managed this reputation so as greatly to promote their own particular advantage. They accordingly allowed no man to consult the gods, before he had offered costly sacrifices, and made rich presents to them. And to keep up the veneration for their oracles, and to prevent their being taken unprepared, they admitted persons to consult the gods only at certain stated times; and sometimes they were so cautious, that the greatest personages could obtain no answer at all. Thus Alexander himself was peremptorily denied by the Pythia, or priestess of Apollo, till she was by downright force obliged to ascend the tripod; when, being unable to resist any longer, she cried out, *Thou art invincible*: and these words were accepted instead of a farther oracle.

Of the ambiguity of oracles, the following, out of a great many examples, may be mentioned. Cræsus having received from the Pythoness this answer, That by passing the river Halys, he would destroy a great empire; he understood it to be the empire of his enemy, whereas he destroyed his own.—The oracle consulted by Pyrrhus gave him an answer, which might be equally understood of the victory of Pyrrhus, and the victory of the Romans his enemies:

Aio te, Æacida, Romanos vincere posse.

The equivocation lies in the construction of the Latin tongue, which cannot be rendered in English.—The Pythoness advised Cræsus to guard against the mule. The king of Lydia understood nothing of the oracle, which denoted Cyrus descended from two different nations; from the Medes, by Mandana his mother, the daughter of Astyages; and from the Persians, by his father Cambyfes, whose race was by far less grand and illustrious.—Nero had for answer, from the oracle of Delphos, that seventy-three might prove fatal to him. He believed he was safe from all danger till that age; but, finding himself deserted by every one, and hearing Galba proclaimed emperor, who was 73 years of age, he was sensible of the deceit of the oracle.

When men began to be better instructed by the lights philosophy had introduced into the world, the false oracles insensibly lost their credit. Chrysippus filled an entire volume with false or doubtful oracles. Oenomaus, to be revenged of some oracle that had deceived him, made a compilation of oracles, to show their

Oracle. their ridiculous vanity. Eusebius has preserved some fragments of this criticism on oracles by Oenomaus. "I might (says Origen) have recourse to the authority of Aristotle and the Peripatetics, to make the Pythoness much suspected; I might extract from the writings of Epicurus and his sectators an abundance of things to discredit oracles; and I might show that the Greeks themselves made no great account of them."

The reputation of oracles was greatly lessened when they became an artifice of politics. Themistocles, with a design of engaging the Athenians to quit Athens, and to embark, in order to be in a better condition to resist Xerxes, made the Pythoness deliver an oracle, commanding them to take refuge in wooden walls. Demosthenes said, that the Pythoness *Philippised*; to signify that she was gained over by Philip's presents.

The cessation of oracles is attested by several profane authors; as Strabo, Juvenal, Lucan, and others. Plutarch accounts for it, by saying, that the benefits of the gods are not eternal as themselves are; or that the genii, who presided over oracles, are subject to death; or that the exhalations of the earth had been exhausted. It appears that the last reason had been alleged in the time of Cicero, who ridicules it in his second book of Divination, as if the spirit of prophecy, supposed to be excited by subterraneous effluvia, had evaporated by length of time, as wine or pickle by being long kept.

Suidas, Nicephorus, and Cedrenus, relate, that Augustus, having consulted the oracle of Delphos, could obtain no other answer but this: "The Hebrew child whom all the gods obey, drives me hence, and sends me back to hell: get out of this temple without speaking one word." Suidas adds, that Augustus dedicated an altar in the Capitol, with this inscription, "To the eldest Son of God." Notwithstanding these testimonies, the answer of the oracle of Delphos to Augustus seems very suspicious. Cedrenus cites Eusebius for this oracle, which is not now found in his works; and Augustus's peregrination into Greece was 18 years before the birth of Christ.

Suidas and Cedrenus give an account also of an ancient oracle delivered to Thulis, a king of Egypt, which they say is well authenticated. The king having consulted the oracle of Serapis, to know if there ever was, or would be, one so great as himself, received this answer: "First, God, next the Word, and the Spirit with them. They are equally eternal, and make but one, whose power will never end. But thou, mortal, go hence, and think that the end of the life of man is uncertain."

Van Dale, in his treatise of oracles, does not believe that they ceased at the coming of Christ. He relates several examples of oracles consulted till the death of Theodosius the Great. He quotes the laws of the emperors Theodosius, Gratian, and Valentinian, against those who consulted oracles, as a certain proof that the superstition of oracles still subsisted in the time of those emperors.

According to others, the opinion of those who believe that dæmons had no share in the oracles, and that the coming of the Messiah made no change in

them, and the contrary opinion of those who pretend that the incarnation of the Word imposed a general silence on all oracles, should be equally rejected. They allege, that two sorts of oracles ought to be distinguished: the one dictated by the spirits of darkness, who deceived men by their obscure and doubtful answers; the other, the pure artifice and cheat of the priests of false divinities. As to the oracles given out by dæmons, the reign of Satan was destroyed by the coming of the Saviour; truth shut the mouth of lies; but Satan continued his old craft among idolaters. All the devils were not forced to silence at the same time by the coming of the Messiah; it was on particular occasions that the truth of Christianity, and the virtue of Christians, imposed silence on the devils. St Athanasius tells the Pagans, that they have been witnesses themselves that the sign of the cross puts the devils to flight, silences oracles, and dissipates enchantments. This power of silencing oracles, and putting the devils to flight, is also attested by Arnobius, Lactantius, Prudentius, Minutius Felix, and several others. Their testimony is a certain proof that the coming of the Messiah had not imposed a general silence on oracles.

Plutarch relates, that the pilot Thamus heard a voice in the air, crying out, "The great Pan is dead;" whereupon Eusebius observes, that the accounts of the death of the dæmons were frequent in the reign of Tiberius, when Christ drove out the wicked spirits.

The same judgment, it is said, may be passed on oracles as on *possessions*. It was on particular occasions, by the divine permission, that the Christians cast out devils, or silenced oracles, in the presence, and even by the confession, of the Pagans themselves. And thus it is we should, it seems, understand the passages of St Jerom, Eusebius, Cyril, Theodoret, Prudentius, and other authors, who said that the coming of Christ had imposed silence on the oracles.

As to the second sort of oracles, which were pure artifices and cheats of the priests of false divinities, and which probably exceeded the number of those that immediately proceeded from dæmons, they did not cease till idolatry was abolished, though they had lost their credit for a considerable time before the coming of Christ. It was concerning this more common and general sort of oracles that Minutius Felix said, they began to discontinue their responses, according as men began to be more polite. But, however oracles were decried, impostors always found dupes, the grossest cheats having never failed.

Daniel discovered the imposture of the priests of Bel, who had a private way of getting into the temple to take away the offered meats, and who made the king believe that the idol consumed them.—Mundus, being in love with Paulina, the eldest of the priestesses of Isis, went and told her, that the god Anubis, being passionately fond of her, commanded her to give him a meeting. She was afterwards shut up in a dark room, where her lover Mundus, whom she believed to be the god Anubis, was concealed. This imposture having been discovered, Tiberius ordered those detestable priests and priestesses to be crucified, and with them Idea, Mundus's free-woman, who had conducted the whole intrigue. He also commanded

Oracle. the temple of Isis to be levelled with the ground, and her statue to be thrown into the Tiber; and, as to Mundus, he contented himself with sending him into banishment.

Theophilus, bishop of Alexandria, not only destroyed the temples of the false gods, but discovered the cheats of the priests, by showing that the statues, some of which were of brass, and others of wood, were hollow within, and led into dark passages made in the wall.

Lucian, in discovering the impostures of the false prophet Alexander, says, that the oracles were chiefly afraid of the subtilties of the Epicureans and Christians. The false prophet Alexander sometimes feigned himself seized with a divine fury, and by means of the herb sopewort, which he chewed, frothed at the mouth in so extraordinary a manner, that the ignorant people attributed it to the strength of the god he was possessed by. He had long before prepared a head of a dragon made of linen, which opened and shut its mouth by means of a horse-hair. He went by night to a place where the foundations of a temple were digging; and having found water, either of a spring, or rain that had settled there, he hid in it a goose-egg, in which he had inclosed a little serpent that had been just hatched. The next day, very early in the morning, he came quite naked into the street, having only a scarf about his middle, holding in his hand a scythe, and tossing about his hair as the priests of Cybele; then getting a-top of a high altar, he said that the place was happy to be honoured by the birth of a god.—Afterwards, running down to the place where he had hid the goose-egg, and going into the water, he began to sing the praises of Apollo and Æsculapius, and to invite the latter to come and show himself to men. With these words, he dips a bowl into the water, and takes out a mysterious egg, which had a god inclosed in it; and when he had it in his hand, he began to say that he held Æsculapius. Whilst all were eager to have a sight of this fine mystery, he broke the egg, and the little serpent starting out, twisted itself about his fingers.

These examples show clearly, that both Christians and Pagans were so far agreed as to treat the greater number of oracles as purely human impostures.—That, in fact, ALL of them were so, will be concluded by those who give equal credit to *dæmoniacal inspiration*, and *dæmoniacal possession*. The most ancient oracle was that of Dodona (see DODONA); but the most famous was that of Delphi, to which article we also refer for further particulars on this subject, so famous in Pagan antiquity. Another celebrated one was the oracle of Trophonius, in the neighbourhood of Lebadia, a city of Bœotia, which was held in high estimation. It received its name from Trophonius, brother of Agamedes, who lived in a subterraneous dwelling near Lebadia, and pretended to the faculty of foretelling future events. He died in his cave, and was deified as an oracular god. This oracle owed its reputation to one Saon.

Those who repaired to this cave for information, were required to offer certain sacrifices, to anoint themselves with oil, and to bathe in a certain river: They were then clothed in a linen robe, took a ho-

neyed cake in their hands, and descended into the subterraneous chamber by a narrow passage. Here it was that futurity was unfolded to them, either by visions or extraordinary sounds. The return from the cave was by the same passage, but the persons consulting were obliged to walk backwards. They generally came out astonished, melancholy, and dejected; hence the proverb, *ἵς Τροφονίου μεμάρτυται*. The priests on their return placed them on an elevated seat, called the seat of *Mnemosyne*, where an account was taken of what they had seen and heard. They were then conducted to the chapel of good Genius by their companions, where, by degrees, they recovered their usual composure and cheerfulness.

Besides these three principal oracles of Greece, it is proper to take notice of that of Amphiaraus at Oropus in Attica. It was so called from Amphiaraus, the son of Oicleus, a man skilled in magic, the interpretation of dreams, &c. and who after his death was deified and delivered oracles in a temple erected to his divinity. (See AMPHIARAUS.) They who applied to him for information, were to purify themselves, offer sacrifice, fast twenty-four hours, abstain from wine two days, and make an offering of a ram to Amphiaraus; on the skin of which they were to sleep, and see their destiny in a dream. Near the temple was Amphiaraus's fountain, which was sacred, and the waters of it forbidden to be used for ordinary purposes.

At Delos also there was an oracle of the Delian Apollo: in Milefia was that of the Branchidæ, with others of less note, which require not a particular description, such as that of the camps at Lacedæmon, that of Nabarcha, that of Chrysopolis, that of Claros in Ionia, that of Mallos, that of Patarea, that of Pella, that of Phaselides, that of Sinope, that of Orpheus's head, &c.

Though the Romans consulted the Grecian oracles upon many occasions, and had few oracles in their own country; yet we must not omit mentioning the Cuman oracles, which were delivered by the Sibyl of Cumæ. For an account of the Sibyls, see the article SIBYL. See also DÆMON and DÆMONIAC.

We have hitherto only considered the oracles of false gods, of which there was a far greater number than our limits permit us to observe, and before either Greeks or Romans had risen to any distinction. Oracle is in sacred history sometimes used for the mercy-seat, or the cover of the ark of the covenant; and by others it is taken for the sanctuary, or for the most holy place, wherein the ark was deposited.

Among the Jews we may distinguish several sorts of real oracles. They had first oracles that were delivered *viva voce*; as when God spake to Moses face to face, and as one friend speaks to another, (Numb. xii. 8.) Secondly, Prophetical dreams sent by God; as the dreams which God sent to Joseph, and which foretold his future greatness, (Gen. xxxvii. 5, 6.) Thirdly, Visions; as when a prophet in an ecstasy, being neither properly asleep nor awake, had supernatural revelations, (Gen. xv. 1. xvi. 2.) Fourthly, The oracle of Urim and Thummim, which was accompanied with the ephod or the pectoral worn by the high-priest, and which God had endued with the gift of foretelling things.

Oracle.

Oracle. things to come, (Numb. xii. 6. Joel ii. 28.) This manner of inquiring of the Lord was often made use of, from Joshua's time to the erection of the temple at Jerusalem. Fifthly, After the building of the temple, they generally consulted the prophets, who were frequent in the kingdoms of Judah and Israel. From Haggai, Zechariah, and Malachi, who are the last of the prophets that have any of their writings remaining, the Jews pretend that God gave them what they call *Bathcol*, the daughter of the voice, which was a supernatural manifestation of the will of God, which was performed either by a strong inspiration or internal voice, or else by a sensible and external voice, which was heard by a number of persons sufficient to bear testimony of it. For example, such was the voice that was heard at the baptism of Jesus Christ, saying, This is my beloved son, &c. (Matth. iii. 17.)

The scripture affords us examples likewise of profane oracles. Balaam, at the instigation of his own spirit, and urged on by his avarice, fearing to lose the recompense that he was promised by Balak king of the Moabites, suggests a diabolical expedient to this prince, of making the Israelites fall into idolatry and fornication (Numb. xxiv. 14. xxxi. 16.), by which he assures him of a certain victory, or at least of considerable advantage against the people of God.

Micaiah the son of Imlah, a prophet of the Lord, says (1 Kings xxii. 21, &c.), that he saw the Almighty sitting upon his throne, and all the host of heaven round about him; and the Lord said, Who shall tempt Ahab king of Israel, that he may go to war with Ramoth-gilead, and fall in the battle? One answered after one manner, and another in another. At the same time an evil spirit presented himself before the Lord and said, I will seduce him. And the Lord asked him, How? To which Satan answered, I will go and be a lying spirit in the mouth of his prophets. And the Lord said, Go, and thou shalt prevail. This dialogue clearly proves these two things, *first*, that the devil could do nothing by his own power; and, *secondly*, that with the permission of God, he could inspire the false prophets, forcerers, and magicians, and make them deliver false oracles.

Respecting the cessation of profane oracles there have been a variety of opinions; some of which we have already remarked. It has been generally held, indeed, that oracles ceased at the birth of Jesus Christ: Yet some have endeavoured to maintain the contrary, by showing that they were in being in the days of Julian, commonly called *the Apostate*, and that this emperor himself consulted them; nay, farther, say they, history makes mention of several laws published by the Christian emperors Theodosius, Gratian, and Valentinian, to punish persons who interrogated them, even in their days; and that the Epicureans were the first who made a jest of this superstition, and exposed the roguery of its priests to the people. As we suspect most of the facts here asserted should be understood in a qualified sense, we shall endeavour to discuss this point of controversy in as few words as possible, although it is undoubtedly a matter of some consequence.

1st, The question, properly stated, is not, Whether oracles became extinct *immediately upon the birth of Christ*, or from the very moment he was born? but, If they fell gradually into disesteem and ceased, as
N^o 250.

Christ and his gospel became known to mankind? And that they did so, is most certain from the concurrent testimonies of the fathers, which, who ever would endeavour to invalidate, may equally give up the most respectable traditions and relations of every kind.

2dly, But did not Julian, the apostate, consult these oracles? we answer in the negative: he had indeed recourse to magical operations, but it was because oracles had already ceased; for he bewailed the loss of them, and assigned pitiful reasons for it; which St Cyrill has vigorously refuted, adding, that *he never could have offered such, but from an unwillingness to acknowledge, that when the world had received the light of Christ, the dominion of the devil was at an end.*

3dly, The Christian emperors do indeed seem to condemn the superstition and idolatry of those who were still for consulting oracles; but the edicts of those princes do not prove that oracles actually existed in their times, any more than that they ceased in consequence of their laws. It is certain that they were for the most part extinct before the conversion of Constantine.

4thly, Some Epicureans might make a jest of this superstition: however the Epicurean philosopher Cellus, in the second century of the church, was for crying up the excellency of several oracles, as appears at large from Origen's seventh book against him.

ORÆA, certain solemn sacrifices of fruits which were offered in the four seasons of the year, in order to obtain mild and temperate weather. They were offered to the goddesses who presided over the seasons, who attended upon the sun, and who received divine worship at Athens.

ORAL, something delivered by word of mouth, without being committed to writing; in which sense we say oral law, oral tradition, &c.

ORAN, a very strong and important town of Africa, in Barbary, and in the kingdom of Tremecen, with several forts, and an excellent harbour. It is seated partly on the side of a hill, and partly on a plain, about a stone-cast from the sea, almost opposite to Carthagen in Spain. It is about a mile and an half in circumference, and well fortified, but commanded by the adjacent hills. It was taken by the Spaniards in 1509, and retaken by the Algerines in 1708; but in 1732 the Spaniards became masters of it, and have continued so ever since. E. Long. o. 8. N. Lat. 36. 2.

ORANG OUTANG. See SIMIA. Also COMPARATIVE ANATOMY, p. 250, ch. 1. sect. 2.

ORANGE, a famous city, and capital of a province of the same name, united to Dauphiny, with a university and a bishop's see, suffragan of Arles. It is seated in a fine large plain, watered by a vast number of little rivulets on the east side of the river Rhone. It is a very large ancient place, and was considerable in the time of the Romans, who adorned it with several buildings, of which there are still some ruins left, particularly of an amphitheatre, and a triumphal arch, which is almost entire, dedicated to Marius. This town was formerly much larger than it is at present, as appears from the traces of the ancient walls. The wall was in 1682 entirely demolished by order of Louis XIV. and the inhabitants were exposed to the fury of the soldiers. The town was restored to King William by the treaty of Ryswick; but after his death

Orange.

death the French took it again, and expelled the protestant inhabitants. By the treaty of Utrecht it was confirmed to the crown of France, though the title is still retained in the house of Nassau. The title was first introduced into the family of Nassau by the marriage of Claude de Chalons, the prince of Orange's sister, with the count of Nassau, 1530. The principality is a very small district, it being only twelve miles in length and nine in breadth, and the revenue amounts to about 5000 l. a-year. The country is pleasant, and abounds with corn and fruit, but is exposed to violent winds. E. Long. 4. 49. N. Lat. 44. 9.

Maurice Prince of ORANGE. See MAURICE.

ORANGE Tree, in botany. See the article CITRUS.

—Orange-flowers are justly esteemed one of the finest perfumes; and though little used in medicine, yet the water distilled from them is accounted stomachic, cordial, and carminative. The fruit is cooling, and good in feverish disorders, and particularly in diarrhoeas. Orange-peel is an agreeable aromatic, proper to repair and strengthen the stomach, and gives a very grateful flavour to any infusions or tinctures into whose compositions it enters. It is particularly useful in preparations of the bark; gives an agreeable warmth to the infusion; and, according to Dr Percival, considerably increases its virtue.

In the Philosophical Transactions, n^o 114, there is a very remarkable account of a tree standing in a grove near Florence, having an *orange* stock, which had been so grafted upon, that it became in its branches, leaves, flower, and fruit, three-formed: some emulating the orange, some the lemon or citron, and some partaking of both forms in one; and what was very remarkable, was, that these mixed fruits never produced any perfect seeds; sometimes there were no seeds at all in them, and sometimes only a few empty ones.

ORANGE-Peel. See CITRUS and *ORANGE-Tree*.

ORANGE-Dew, a kind of dew which falls in the spring-time from the leaves of orange and lemon trees, which is extremely fine and subtle. M. de la Hire observing this, placed some flat pieces of glass under the leaves to receive it; and having procured some large drops of it, was desirous of discovering what it was. He soon found that it was not a merely aqueous fluid, because it did not evaporate in the air; and that it was not a resin, because it readily and perfectly mixed with water: it was natural then to suppose it a liquid gum; but neither did this, on examination, prove to be the case; for being laid on paper, it did not dry as the other liquid gums do. Its answering to none of these characters, and its being of the consistence of honey, and of a sweet sugar-like taste, gave a suspicion of its being a kind of manna; and whatever in the other trials had proved it not a resin, a gum, &c. all equally tends to prove that it is this substance.

ORANGE-Sea, in natural history, a name given by Count Marfigli to a very remarkable species of marine substance, which he denominates a *plant*. It is tough and firm in its structure, and in many things resembles the common fucus; but instead of growing into the branched form which the generality of those substances have, it is round and hollow, and in every respect resembles the shape of an orange. It has, by way of root, some exceeding fine filaments, which fasten themselves to the rocks, or to shells, stones, or any thing else that comes in the way. From these there grows no

pedicle; but the body of the orange, as it is called, is fastened by them to the rock, or other solid substance. The orange itself is usually of about three or four inches in diameter; and while in the sea, is full of water, and even retains it when taken up. In this state it frequently weighs a pound and a half; but when the water is let out, and it is dried, it becomes a mere membrane, weighing scarce any thing. It is best preserved, by stuffing it with cotton as soon as the water is let out of it, and then hanging it up to dry. Its surface is irregular and rough, and its colour a dusky green on the outside, and a clearer but somewhat bluish green within; and its thickness is about an eighth part of an inch. When viewed by the microscope, it is seen to be all over covered with small glandules, or rather composed of them; for they stand so thick one by another as to leave no space between, and seem to make up the whole substance; so that it appears very like the rough shagreen skin used to cover toys. These are indeed so many hollow ducts, through which the sea-water finds a passage into the globe formed by this skin, and by this means it is kept always full and distended; on cutting it with a pair of scissors, the water immediately runs out, and the skins collapse; but there is something extremely remarkable in this, for the whole substance, near the wounded place, is in motion, and seems as if alive, and sensible of the wound. The glandules are found full of water, and resembling small transparent bottles; and what goes to the structure of the plant beside these, is an assemblage of a vast number of filaments, all which are likewise hollow, and filled with a clear and transparent fluid.

There is another substance of this kind, mentioned and described by Count Marfigli, Triumfetti, and others, and called the *ramose* or branched orange. This is very much of the nature of the former; but, instead of consisting of one round globule, it is formed of several oblong ones, all joined together, and representing the branches of some of the fucuses, only they are shorter; and these are all hollow and full of water, in the same manner as the single globes of the common kind. This has, by way of root, certain fine and slender filaments, which fasten it to the stones or shells near which it is produced; and it is of a dusky greenish colour on the surface, and of a fine bluish green within. The surface, viewed by the microscope, appears rough, as in the other, and the glandules are of the same kind, and are always found full of clear water. See CORALLINES.

ORATION, in rhetoric, a speech or harangue, composed according to the rules of oratory, but spoken in public. Orations may be reduced to three kinds viz. the demonstrative, deliberative, and judicial. To the demonstrative kind belong panegyrics, genethliaca, epithalamia, congratulations, &c. To the deliberative kind belong persuasion, exhortation, &c. And to the judicial kind belong accusation, confutation, &c.

Funeral ORATION. See FUNERAL Oration.

ORATOR, among the Romans, differed from a *patronus*: The latter was allowed only to plead causes on behalf of his clients; whereas the former might quit the forum and ascend the rostra or tribunal, to harangue the senate or the people. The orators had rarely a profound knowledge of the law, but they were eloquent, and their style was generally correct

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||
Orator.

Marfigli,
*Hist. de la
Mer.*

Orator.

and concise. They were employed in causes of importance, instead of the common patrons. Orators, in the violence of elocution, used all the warmth of gesture, and even walked backwards and forwards with great heat and emotion. This it was which occasioned a witticism of Flavius Virginius, who asked one of those walking orators, *Quot millia passuum declamasset?* "How many MILES he had declaimed?" Similar to the Roman orators were the Grecian *Rhetores*. See RHETORES.

Public ORATOR, an office of very considerable dignity, and of some emolument in the English universities.

The public orator is the principal, and in many cases the only ostensible, agent for the university in all those matters or forms which are merely external. He carries on or superintends all correspondences which are calculated to promote the dignity, or raise the utility, of the seminary which constitutes him. He has little to do, indeed, with the internal government of the body, for which a variety of officers in different departments are appointed; but in all public affairs he is, as it were, the mouth of the whole; putting their deliberations into proper form, and communicating or publishing them, according to the intention of the university. Thus, if the whole university, or a committee appointed by them, or by statute, or by the will of any particular benefactor, have, after a comparative trial, adjudged a prize to any person or persons, it is the business of the public orator to inform the successful parties of the issue of the trial. Again, if for singular learning, or for any remarkable *good will* shown to the university by any person or persons, the *senate* or *convocation* are pleased to declare their grateful sense of it, either by conferring degrees, or otherwise as they think fit, the public orator is to notify this intention to the person or persons concerned; and so in other cases.

Another part of the public orator's business is to present young noblemen, or those who take *honorary* degrees, *tantum nobiles*, to the vice-chancellor: this he does in a Latin speech, which, according to circumstances, is either short or long; and of which the subject is generally a defence of that particular statute

which allows the sons of noblemen, and some few others, to proceed to degrees before what is called the *statutable time*. In doing this, encomiums, often stronger than just, are made upon the learning and virtue of the noble candidate; a view is taken of the dignity of his ancient house; the honour is mentioned which has accrued to the university from the accession of such a member; and the oration concludes with promising great credit from his future conduct, as well as benefit from the influence of his rank in the state. These circumstances are deemed sufficient grounds for exempting the sons of noblemen from that tedious course of study through which the duller sons of commoners must all pass before they be thought worthy of academical honours.

ORATORIO, in the Italian music, a sort of sacred drama of dialogues; containing recitatives, duettos, trios, ritornellos, choruses, &c. The subjects of those pieces are usually taken from scripture, or the life of some saint, &c. The music for the oratorios should be in the finest taste and best chosen strains. These oratorios are greatly used at Rome in the time of Lent, and of late in England.

Menestrier attributes the origin of oratorios to the crusades, and says that the pilgrims returning from Jerusalem and the Holy Land, &c. composed songs, reciting the life and death of the Son of God, and the mysteries of the Christian faith, and celebrating the achievements and constancy of saints and martyrs. Others, with more probability, observe, that the oratorio was an avowed imitation of the opera, with only this difference, that the foundation of it was always some religious, or at least some moral subject. Crescimbeni ascribes its origin to San Filippo Neri, who was born at Florence in 1515, and who, in his chapel, after sermons, and other devotions, in order to allure young people to pious offices, had hymns, psalms, and such like prayers, sung by one or more voices. Among these spiritual songs were dialogues; and these entertainments becoming more frequent, and improving every year, were the occasion that in the seventeenth century oratorios were first invented, so called from the place of their origin. See *Hawkins's History of Music*.

Oratorio.

O R A T O R Y;

The art of speaking well upon any subject, in order to persuade.

INTRODUCTION.

§ 1. *Of the Rise and Progress of Oratory.*

THE invention of oratory is by the Egyptians, and the fables of the poets, ascribed to Mercury. And it is well known, that the Greeks made their deities the authors likewise of other arts, and supposed that they presided over them. Hence they gave Mercury the titles of *Λογιστής* and *Ἑρμῆς*, both which names come from words that signify "to speak." And Aristides calls eloquence *the gift of Mercury*; and for the same reason anciently the tongue was consecrated to him. He was likewise said to be the interpreter or

messenger of the gods; which office very well suited him, as he excelled in eloquence. Hence we read in the Sacred Writings, that when the people of Lystra took Barnabas and Paul for gods in human shape, because of that sudden and surprising cure which was wrought upon the lame man, they called Barnabas *Jupiter*, and Paul *Mercury*; for this reason, as the inspired writer tells us, "because he was the chief speaker," that is (as the spectators then thought), the interpreter or spokesman of Barnabas.

But to pass over these fictions of the heathen deities, let us hear what Quintilian says of the *origin* of this art; who seems to give a very probable account of it in the following passage. "The faculty of speech (says

The origin
of the art
of oratory.

(says he) we derive from nature (A); but the art from observation. For as in physic, men, by seeing that some things promote health and others destroy it, formed the art upon those observations; in like manner, by perceiving that some things in discourse are said to advantage, and others not, they accordingly marked those things, in order to imitate the one and avoid the other. They also added some things from their own reason and judgment, which being confirmed by use, they began to teach others what they knew themselves." But no certain account can be given when, or by whom, this method of observation first began to take place. And Aristotle supposes, not without reason, that the first lineaments of the art were very rude and imperfect. Pausanias, indeed, in his *Description of Greece*, tells us, that Pittheus, the uncle of Theseus, taught it at Trezene a city of Peloponnesus, and wrote a book concerning it; which he read himself, as it was published by one of Epidaurus. But as Pittheus lived about 1000 years before Pausanias, who flourished in the time of the emperor Hadrian, some are of opinion he might be imposed upon by the Epidaurian, who published this book under the name of *Pittheus*. But be that as it will, it is very reasonable to believe, that the Greeks had the principles of this art so early as the time of Pittheus. For Theseus his nephew lived not long before the taking of Troy, which, according to Sir Isaac Newton, happened 904 years before the birth of Christ; at which time Cicero thought it was in much esteem among them. "Homer (says he) would never have given Ulysses and Nestor in the Trojan wars so great commendations on account of their speeches (to one of whom he attributes force, and to the other sweetness of expression), if eloquence had not in those times been in great repute." And lest any one should imagine, that in those days they made use only of such helps as nature and practice could afford them, the same poet informs us, that Peleus sent Phoenix with his son Achilles to the Trojan war, to instruct him not only in the art of war, but likewise of eloquence. But who were the professors of this art for some ages following is not known. For Quintilian says, that afterwards Empedocles is the first upon record who attempted any thing concerning it. And he, by Sir Isaac Newton's account, flourished about 500 years after Troy was taken. At which time, as Cicero observes, men being now sensible of the powerful charms of oratory, and the influence it had upon the mind, there immediately arose several masters of it; the chief of whom are mentioned by Quintilian, who tells us, that 'the oldest writers upon this art are Corax and Tisias, both of Sicily. After them came Gorgias of Leontium in the same island, who is said to have been the scholar of Empedocles, and by reason of his great age (for he lived to be 109 years old) had many cotemporaries. Thrasymachus of Chalcedon, Prodicus of Cea, Protagoras of Abdera, Hippias of Elis, and Alcidas of Elea, lived in his

time; as likewise Antiphon, who first wrote orations, and also upon the art, and is said to have spoken admirably well in his own defence; and besides these, Polycrates, and Theodore of Byzantium.' These persons contributed different ways towards the improvement of the art. Corax and Tisias gave rules for methodizing a discourse, and adjusting its particular parts; as may be conjectured from Cicero's account of them, who says, "Though some had spoke well before their time, yet none with order and method." But Gorgias seems to have excelled all the rest in fame and reputation: for he was so highly applauded by all Greece, that a golden statue was erected to him at Delphos, which was a distinguishing honour conferred upon him only. And he is said to have been so great a master of oratory, that in a public assembly he would undertake to declaim immediately upon any subject proposed to him. He wrote, as Cicero informs us, in the demonstrative or laudatory way; which requires most of the sublime, and makes what Diodorus Siculus says of him the more probable, that "he first introduced the strongest figures, members of periods opposite in sense, of an equal length, or ending with a like sound, and other ornaments of that nature." And hence those figures, which give the greatest force and lustre to a discourse, were anciently called by his name. Cicero tells us further, that Thrasymachus and Gorgias were the first who introduced numbers into prose, which Isocrates afterwards brought to perfection. Quintilian likewise mentions Protagoras, Gorgias, Prodicus, and Thrasymachus, as the first who treated of common places, and showed the use of them for the invention of arguments. Nor must we omit Plato, whose elegant dialogue upon this subject is still extant, which he intitles *Gorgias*. For though he does not lay down the common rules of the art; yet he very well explains the nature of it, and maintains its true end and use against the generality of its professors, who had greatly perverted the original design of it. Thus by the study and industry of so many ingenious and great men, the art of oratory was then carried to a considerable height among the Grecians. Though many of those who professed it in those times employed their skill rather to promote their own reputation and applause, than to serve the real interests of truth and virtue. "For they proposed in an arrogant manner (as Cicero says) to teach how a bad cause might be so managed, as to get the better of a good one." That is, they would undertake to charm the ears and strike the passions of their hearers in so powerful a manner, by sophistical reasonings, turns of wit, and fine language, as to impose falsehood upon them for truth; than which nothing could be either more disingenuous in itself, or prejudicial to society.

But those who succeeded them seem to have consulted better, both for their own honour and that of their profession. Isocrates was the most renowned of

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all

2
Orators of
Greece.

(A) If Quintilian meant that the human race speak an articulate language by nature or instinct, he certainly deceived himself (see LANGUAGE); but if his meaning was only that men have from nature a capability of speech, the observation is true, but not of much value. Parrots and other birds have a capability of uttering articulate sounds.

all Gorgias's scholars, whom Cicero frequently extols with the highest commendations, as the greatest master and teacher of oratory; "whose school (as he says) like the Trojan horse, sent forth abundance of great men." Aristotle was chiefly induced to engage in this province from an emulation of his glory; and would often say in a verse of Sophocles, somewhat varied to his purpose,

To be silent it is a shame;
While Isocrates gets such fame.

Quintilian says they both wrote upon the art, though there is no system of the former now extant. But that of Aristotle is esteemed the best and most complete of any in the Greek language. In this age the Grecian eloquence appeared in its highest perfection. Demosthenes was an hearer both of Isocrates and Plato, as also of Isæus (ten of whose orations are yet extant); and by the assistance of a surprising genius, joined with indefatigable industry, made that advantage of their precepts, that he has been always esteemed by the best judges the prince of Grecian orators. His great adversary and rival Æschines, after his banishment, is said to have gone to Rhodes, and employed his time there in teaching of rhetoric. Theodectes and Theophrastus, both of them scholars of Aristotle, imitated their master in writing upon the art. And from that time the philosophers, especially the stoics and peripatetics, applied themselves to lay down the rules of oratory; which Socrates had before separated from the province of a philosopher. And there is yet preserved a treatise upon this subject, which some have ascribed to Demetrius Phalereus the peripatetic, and scholar of Theophrastus, though others more probably to Dionysius of Halicarnassus. Quintilian mentions several other famous rhetoricians in the following ages, who were likewise writers; as Hermagoras, Athenæus, Apollonius Molon, Areus Cæcilius, Dionysius of Halicarnassus, Apollonius of Pergamus, and Theodore of Gadara. But of these nothing now remains upon the subject of oratory, except some tracts of Dionysius, who flourished in the reign of Augustus Cæsar. Nor have there been wanting some eminent writers of this kind among the Greeks since the time of Quintilian; two of whom we cannot omit to mention, Hermogenes, and Longinus the author of the incomparable treatise *Of the Sublime*, a book which can scarce be too much commended or too often read.

3
Rise and
progress of
oratory in
Rome.

It was long before Rome received this art, and not without difficulty at first. The reason was, because the Romans were for several ages wholly addicted to military affairs, and to enlarge their territories; so that they not only neglected to cultivate learning, but thought the pursuit of it a thing of ill tendency, by diverting the minds of their youth from the cares and toils of war, to a more soft and indolent kind of life. Therefore so late as the year of their city 592, when by the industry of some Grecians the liberal arts began to flourish in Italy, a decree passed the senate, by which all philosophers and rhetoricians were ordered to depart out of Rome. But in a few years after, when Cæneades, Critolaus, and Diogenes, who were not only philosophers but orators, came ambassadors from Athens to Rome, the Roman youth were so charmed with the eloquence of their harangues, that

they could no longer be stopt from pursuing the study of oratory. And by a further acquaintance with the Greeks, it soon gained such esteem, that persons of the first quality employed their time and pains to acquire it. And a young gentleman, who was ambitious to advance himself in the service of his country, could have little hopes of success, unless he had laid the foundation of his future prospects in that study.

Seneca tells us, that Lucius Plotius, a Gaul, was the first who taught the art of oratory at Rome in Latin; which Cicero says, was while he was a boy; and when the most studious persons went to hear him, he lamented that he could not go with them; being prevented by the regard he paid to the opinion of some of his friends, who thought that greater improvements were made by exercises in the Greek language under Grecian masters. Seneca adds, that this profession continued for some time in the hands of freedmen; and that the first Roman who engaged in it was Blandus of the equestrian order, who was succeeded by others; some of whose lives are yet extant, written by Suetonius, as many of the Grecians are by Philostratus and Eunapius. Quintilian likewise gives us the names of those among the Romans, who wrote upon the art. "The first (says he), as far as I can learn, who composed any thing upon this argument, was M. Cato the censor. After him Anthony the orator began upon the subject, which is the only work he has left, and that imperfect. Then followed some of less note. But he who carried eloquence to its highest pitch among us, was Cicero: who has likewise by his rules given the best plan both to practise and teach the art. After whom modesty would require us to mention no more, had he not told us himself, that his books of rhetoric slipped out of his hands, while he was but a youth. And those lesser things, which many persons want, he has purposely omitted in his discourses of oratory. Cornificius wrote largely upon the same subject; Stertinius and Gallio the father, each of them something. But Celsus and Lenas were more accurate than Gallio; and in our times Virginius, Pliny, and Rutilius. And there are at this day some celebrated authors of the same kind, who, if they had taken in every thing, might have saved my pains." Time has since deprived us of most of the writers mentioned here by Quintilian. But we have the less reason to regret this loss, since it has preserved to us Cicero's treatises upon this subject; which we may well suppose to have been chiefly owing to their own excellency, and the great esteem they have always had in the world. Besides his *Two Books of Invention*, which Quintilian here calls his *Books of Rhetoric*, there are extant of his, *Three Books of an Orator*; one *Of famous Orators*; and another, which is called *The Orator*; as also his *Topics*, a preface *Concerning the best sort of Orators*, and a treatise *Of the parts of Oratory*. Each of which treatises, whether we regard the justness and delicacy of the thoughts, the usefulness of the rules, or the elegance and beauty of the style, deserves to be frequently perused by all who are lovers of eloquence. For who can be thought so well qualified to give the rules of any art, as he who excelled all mankind in the practice of them? But those *Four books to Herennius*, which are published among Cicero's works, seem with good reason to be attributed to Cornificius, whom

Quin-

Quintilian here mentions. And Celsus is by some affirmed to have taught oratory, whom he also places among the rhetoricians, and whose *Eight Books of Medicine* are yet extant, written in so beautiful a style as plainly shows him to be a master of eloquence. But Quintilian himself outdid all who went before him in diligence and accuracy as a writer. His *Institutions* are so comprehensive, and written with such great exactness and judgment, that they are generally allowed to be the most perfect work of the kind. With this excellent author we shall finish the account of the Latin rhetoricians.

There were indeed some others in the following ages, whose works are yet extant; but as they contain nothing of moment which is not to be found in those already mentioned, we shall forbear to name them. Much less shall we descend to that numerous body of writers, who since the revival of learning have treated upon this subject, for the same reason. And a very good judge* has not long since given it as his opinion, that the method of forming the best system of oratory, is to collect it from the finest precepts of Aristotle, Cicero, Quintilian, Longinus, and other celebrated authors; with proper examples taken from the choicest parts of the purest antiquity. And this is the method attempted to be pursued in the following treatise.

* Archb.
Cambray,
Lett. p. 213.

§ 2. *Of the Nature of Oratory.*

THE terms *rhetoric* and *oratory*, having no other difference but that one is taken from the Greek language and the other from the Latin, may be used promiscuously: but the case is not the same with respect to the words *rhetorician* and *orator*. For although the Grecians used the former, both to express those who taught the art, and those who practised it; yet the Romans afterward, when they took that word into their language, confined it to the teachers of the art, and called the rest *orators*. And there seems to have been a sufficient reason for this distinction, since the art was the same in both, and might therefore go by either name: but the different province of rhetoricians and orators made it not improper that they should be called by different names. Besides, anciently, before rhetoric was made a separate and distinct art from philosophy, the same persons taught both. And then they were called not only *rhetoricians* but *sophists*. But because they often employed their art rather to vindicate what was false and unjust, than to support truth and virtue; this disingenuous conduct, by which they frequently imposed upon weak minds, brought a discredit both upon themselves and their profession. And therefore the name *sophist*, or *sophister*, has been more generally used in an ill sense, to signify one skilled rather in the arts of cavilling, than qualified to speak well and accurately upon any subject.

4
Oratory an
art.

It is not necessary to use many words, to prove that oratory is an art. For it is comprised under certain rules, agreeable to reason, delivered in a regular method, and suited to attain the end it proposes; which are characters sufficient to denominate it an art. Indeed the case is the same here as in most other things, that a good genius is of itself more serviceable than the most exact acquaintance with all the rules of art, where that is wanting. But it is sufficient that art

help nature, and carry it farther than it can otherwise advance without it. And he who is desirous to gain the reputation of a good orator, will find the assistance of art very necessary. Some persons have thought, that many of the common systems written upon the subject of oratory have been attended with this inconvenience, that, by burdening the mind with too great a number of rules about things of less importance, they have oftentimes rather discouraged than promoted the study of eloquence. This undoubtedly is an extreme which should be always carefully avoided. But, however, an indifferent guide in a strange road is better than none at all. It may be worth while to hear Quintilian's opinion upon this head. "I would not (says he) have young persons think they are sufficiently instructed, if they have learned one of those compends which are commonly handed about, and fancy themselves safe in the decrees, as it were, of these technical writers. The art of speaking requires much labour, constant study, a variety of exercise, many trials, the greatest prudence, and readiness of thought. However, these treatises are useful, when they set you in a plain and open way, and do not confine you to one narrow tract, from which he who thinks it a crime to depart must move as slowly as one that walks upon a rope." We see he is not for having us confine ourselves too closely to systems, though he thinks they are of service at first, till use and experience render them less necessary.

The business of oratory is to teach us to speak well; The object⁵ which, as Cicero explains it, is to speak justly, methodically, floridly, and copiously. of it.

Now, in order to speak justly, or pertinently, a person must be master of his subject, that he may be able to say all that is proper, and avoid whatever may appear foreign and trifling. And he must clothe his thoughts with such words and expressions as are most suited to the nature of the argument, and will give it the greatest force and evidence.

And as it teaches to speak justly, so likewise methodically. This requires, that all the parts of a discourse be placed in their proper order, and with such just connection, as to reflect a light upon each other, and thereby to render the whole both clear in itself, and easy to be retained. But the same method is not proper for all discourses. And very frequently a different manner is convenient in handling the same subject. For it is plain, that art, as well as nature, loves variety; and it discovers the speaker's judgment, when the disposition of his discourse is so framed, as to appear easy and natural, rather than the effect of industry and labour.

To speak floridly, is so peculiar a property of this art, that some have wholly confined it to the pomp and ornaments of language. But that it extends farther, and respects things as well as words, we shall have occasion to show hereafter. It contains indeed the whole subject of elocution, but does not wholly consist in it. True and solid eloquence requires not only the beauties and flowers of language, but likewise the best sense and clearest reasoning. Besides rhetoric gives rules for the several sorts of style, and directs the use of them agreeably to the nature of the subject.

But the force of oratory appears in nothing more than

than a *copiousness* of expression, or a proper manner of enlargement, suited to the nature of the subject; which is of great use in persuasion, and forms the last property, required by Cicero, of speaking well. A short and concise account of things is often attended with obscurity, from an omission of some necessary circumstances relating to them. Or, however, where that is not the case, yet for want of proper embellishments to enliven the discourse, and thereby to excite and fix the hearers attention, it is apt to slip through their minds without leaving any impression. But where the images of things are drawn in their full proportion, painted in their proper colours, set in a clear light, and represented in different views, with all the strength and beauties of eloquence, they captivate the minds of the audience with the highest pleasure, engage their attention, and by an irresistible force move and bend them to the design of the speaker.

The principal end and design of oratory is to persuade: for which reason it is frequently called the *art of persuasion*. Indeed the orator has often other subordinate views; as when he endeavours either to delight his hearers with what is pleasant and agreeable, or to conciliate their good opinion by a smooth and artful address: but still both these are in order to persuade and excite them to action.

An objection may, perhaps, hence be formed against eloquence, as an art which may be employed for persuading to ill as well as to good. There is no doubt that it may; and so reasoning may also be, and too often is, employed for leading men into error. But who would think of forming an argument from this against the cultivation of our reasoning powers? Reason, eloquence, and every art which ever has been studied among mankind, may be abused, and may prove dangerous in the hands of bad men; but it were perfectly childish to contend, that upon this account they ought to be abolished.

While the orator employs his art in pursuing only those ends for which it was at first designed, the persuading men to good and virtuous actions, and dis-

suading them from every thing that is ill and vicious; nothing can be more commendable in itself, or useful to human societies.

§ 3. Of the Division of Oratory.

ORATORY consists of four parts; *invention*, *disposition*, *elocution*, and *pronunciation*. This will appear by considering the nature of each of them, and what it contributes in forming an orator. Every one who aims to speak well and accurately upon any subject, does naturally in the first place inquire after and pursue such thoughts as may seem most proper to explain and illustrate the thing upon which he designs to discourse. And if the nature of it requires that he should bring reasons to confirm what he says, he not only seeks the strongest, and such as are like to be best received; but also prepares to answer any thing which may be offered to the contrary. This is *invention*.—After this he deliberates with himself in what method to dispose of those things which have occurred to his mind, that they may appear in the plainest light, and not lose their force by disorder and confusion. This is the business of *disposition*.—His next concern is to give his thoughts an agreeable dress; by making choice of the fittest words, clearest expressions, smooth and harmonious periods, with other ornaments of style, as may best suit the nature of his subject, brighten his discourse, and render it most entertaining to his hearers. And this is called *elocution*.—The last thing he attends to, is to deliver what he has thus composed, with a just and agreeable *pronunciation*. And daily experience convinces us, how much this contributes both to engage the attention and impress what is spoken upon the mind. This then is the method to which nature directs, in order to qualify ourselves for discoursing to the best advantage: Though by custom and habit these things become so familiar to us, that we do not always attend to them separately in their natural order. However, it is the business of art to follow nature, and to treat of things in that manner which she dictates.

PART I. OF INVENTION.

CHAP. I. Of Invention in general; and particularly of Common Places, and State of a Cause.

⁷ INVENTION, considered in general, is the discovery of such things as are proper to persuade. And in order to attain this end, the orator proposes to himself three things: To prove or illustrate the subject upon which he treats; to conciliate the minds of his hearers; and to engage their passions in his favour. And as these require different kinds of arguments or motives, invention furnishes him with a supply for each of them, as will be shown in their order.

An argument, as defined by Cicero, is a reason which induces us to believe what before we doubted of.

And as different kinds of discourses require different arguments, rhetoricians have considered them two ways; in general, under certain heads, as a common fund for all subjects; and in a more particular manner, as they are suited to *demonstrative*, *deliberative*, or *judicial* discourses.

At present we shall treat only upon the former of these. And now, that one thing may receive proof and confirmation from another, it is necessary that there be some relation between them; for all things are not equally adapted to prove one another. Thus, in measuring the quantity of two things which we would show to be either equal or unequal, if they are of such a nature that one cannot be applied to the other, then we take a third thing, which may be applied to them both; and that must be equal at least to one of the two, which if applied to the other, and found equal to that also, we presently conclude that these two things are equal; but if it be unequal to the other, we say that these two things are unequal. Because it is the certain and known property of all quantities, that whatsoever two things are equal to a third, are equal to one another; and where one of any two things is equal to a third, and the other unequal, those two things are unequal to one another. What has been said of quantities, will hold true in all other cases, that so far as any two things or ideas agree

Invention. agree to a third, so far they agree to one another. So likewise, on the contrary, as far as one of any two things or ideas does agree to a third, and the other does not, so far they disagree with one another; in which respect, one of them cannot be truly affirmed of the other. Since, therefore, in every proposition, one thing is spoken of another, if we would find out whether the two ideas agree to each other or not, where this is not evident of itself, we must find out some third thing, the idea of which agrees to one of them; and then that being applied to the other, as it does agree or disagree with it, so we may conclude, that the two things proposed do agree or disagree with one another. This will be made more clear by an example or two. Should it be inquired, *Whether virtue is to be loved*; the agreement between virtue and love might be found by comparing them separately with happiness, as a common measure to both. For since the idea of happiness agrees to that of love, and the idea of virtue to that of happiness; it follows, that the ideas of virtue and love agree to one another: and therefore it may be affirmed, *That virtue is to be loved*. But on the contrary, because the idea of misery disagrees with that of love, but the idea of vice agrees to that of misery, the two ideas of vice and love must consequently disagree with one another; and therefore it would be false to assert, *That vice is to be loved*. Now, this third thing logicians call the *medium*, or *middle term*, because it does as it were connect two extremes; that is, both parts of a proposition. But rhetoricians call it an *argument*, because it is so applied to what was before proposed, as to become the instrument of procuring our assent to it. Thus far as to the nature and use of arguments. We shall next explain by what methods they are to be sought.

8
These call-
ed argu-
ments.

A lively imagination, and readiness of thought, are undoubtedly a very great help to invention. Some persons are naturally endued with that quickness of fancy, and penetration of mind, that they are seldom at a loss for arguments either to defend their own opinions, or to attack their adversaries. However, these things being the gift of nature, and not to be gained by art, do not properly fall under our present consideration.

9
Learning
necessary to
an orator.

It will be readily granted, that great learning and extensive knowledge are a noble fund for invention. An orator therefore should be furnished with a stock of important truths, solid maxims of reason, and a variety of knowledge, collected and treasured up both from observation and a large acquaintance with the liberal arts; that he may not only be qualified to express himself in the most agreeable manner, but likewise to support what he says with the strongest and clearest arguments.

But because all are not born with a like happy genius, and have not the same opportunity to cultivate their minds with learning and knowledge; and because nothing is more difficult than to dwell long upon the consideration of one thing, in order to find out the strongest arguments which may be offered for and against it; upon these accounts, art has prescribed a method to lessen, in some measure, these difficulties, and help every one to a supply of arguments upon any

subject. And this is done by the contrivance of *common places*, which Cicero calls the *seats* or *heads* of arguments, and by a Greek name *topics*. They are of two sorts, *internal* and *external*.

I. Internal topics. Though things, with regard to their nature and properties, are exceedingly various, yet they have certain common relations, by means whereof the truth of what is either affirmed or denied concerning them in any respect may be evinced. The ancient Greek rhetoricians therefore reduced these relations to some general heads, which are termed *loci* or *common places*; because the reasons or arguments suited to prove any proposition are repositied in them, as a common fund or receptacle. And they are called *internal heads*, because they arise from the subject upon which the orator treats; and are therefore distinguished from others named *external*, which he fetches from without, and applies to his present purpose, as will be shown hereafter. Cicero and Quintilian make them 16; three of which comprehend the whole thing they are brought to prove, namely, *definition*, *enumeration*, and *notation*: of the remaining 13, some contain a part of it, and the rest its various properties and circumstances, with other considerations relating to it; and these are, *genus*, *species*, *antecedents*, *consequents*, *adjuncts*, *conjugates*, *cause*, *effect*, *contraries*, *opposites*, *similitude*, *dissimilitude*, and *comparison*.

Definition explains the nature of the thing defined, and shows what it is. And to whatsoever the definition agrees, the thing defined does so likewise. If therefore Socrates be a rational creature, he is a man; because it is the definition of a man, that he is a rational creature.

Enumeration takes in all the parts of a thing. And from this we prove, that what agrees to all the parts agrees to the whole; and what does not agree to any one or more parts, does not agree to the whole: As when Cicero proves to Piso that all the Roman state hated him, by enumerating the several ranks and orders of Roman citizens who all did so.

Notation, or etymology, explains the meaning or signification of a word. From which we reason thus: "If he cannot pay his debts, he is insolvent;" for that is the meaning of the word *insolvent*.

Genus is what contains under it two or more sorts of things, differing in nature. From this head logicians reason thus: "Because every animal is mortal, and man is an animal, therefore man is mortal." But orators make a further use of this argument, which they call *ascending from the hypothesis to the thesis*; that is, from a particular to a general: As should a person, when speaking in praise of justice, take occasion from thence to commend and show the excellency of virtue in general, with a view to render that particular virtue more amiable. For since every species contains in it the whole nature of the genus to which it relates, besides what is peculiar to itself, whereby it is distinguished from it; what is affirmed of the genus, must of necessity be applicable to the species.

Species is that which comprehends under it all the individuals of the same nature. From hence we may argue, "He is a man, therefore he has a rational soul." And orators sometimes take occasion from this head to descend from the thesis to the hypothesis; that

10
Rules of art
to supply
the place of
extensive
learning or
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nius.

Invention.

that is, in treating upon what is more general, to introduce some particular contained under it, for the greater illustration of the general.

Antecedents are such things, as, being once allowed, others necessarily, or very probably, follow. From this head an inseparable property is proved from its subject: as, It is material, and therefore corruptible.

Consequents are such things as, being allowed, necessarily or very probably infer their antecedents. Hence the subject is proved from an inseparable property, in this manner: It is corruptible, and therefore material.

Adjuncts are separable properties of things, or circumstances that attend them. These are very numerous, and afford a great variety of arguments, some of which usually occur in every discourse. They do not necessarily infer their subject; but, if fitly chosen, render a thing credible, and are a sufficient ground for assent. The way of reasoning from them we shall show presently.

Conjugates are words deduced from the same origin with that of our subject. By these the habit is proved from its acts: as, He who does justly is just. He does not act wisely, therefore he is not wise. But this inference will not hold, unless the actions appear continued and constant.

A *cause* is that, by the force of which a thing does exist. There are four kinds of causes, matter, form, efficient, and end, which afford a great variety of arguments. The way of reasoning from them is to infer the effect from the cause: as, Man is endued with reason, therefore he is capable of knowledge.

An *effect* is that which arises from a cause, therefore the cause is proved by it: as, He is endued with knowledge, therefore with reason.

Contraries are things, which, under the same genus, are at the utmost distance from each other; so that what we grant to the one, we utterly deny the other: as, Virtue ought to be embraced, therefore vice should be avoided.

Opposites are such things, which, though repugnant to each other, yet are not directly contradictory: as, To love and to injure, to hate and to commend. They differ from contraries in this, that they do not absolutely exclude one another. An argument is drawn from things repugnant, thus: He will do a man a mischief, therefore he does not love him. He loves a man, therefore he will not reproach him.

Similitude is an agreement of things in quality. Thus Cicero proves, that pernicious citizens ought to be taken out of the state; by the likeness they bear to corrupted members, which are cut off to prevent further damage to the body.

Dissimilitude is a disagreement of things in quality. From this head Cicero shows the preference of his own exile to Piso's government of Macedonia; by the difference between their conduct, and the people's esteem of them.

Comparison is made three ways: for either a thing is compared with a greater, with a less, or with its equal. This place, therefore, differs from that of similitude on this account, that the quality was considered in that, but here the quantity. An argument from the greater is thus drawn: If five legions could not conquer the enemy, much less will two.

We shall just give one example of the manner of
N^o 250.

reasoning from these heads, whereby the use of them may further appear. If any one, therefore, should have endeavoured to persuade Cicero not to accept of his life upon the condition offered him by Antony, That he would burn his Philippic orations which had been spoken against him, he might be supposed to use such arguments as these; partly taken from the adjuncts of Cicero, partly from those of Antony, and partly from the thing itself. And first with regard to Cicero, it might be said, That so great a man ought not to purchase his life at so dear a price as the loss of that immortal honour which by so great pains and labour he had acquired. And this might be confirmed by another argument, That now he was grown old, and could not expect to live much longer. And from the character of Antony he might argue thus: That he was very crafty and deceitful; and only designed, by giving him hopes of life, to have the Philippics first burnt, which otherwise he knew would transmit to posterity an eternal brand of infamy upon him; and then he would take off the author. And this might be shown by comparison. For since he would not spare others, who had not so highly exasperated him, and from whom he had not so much to fear; certainly he would not forgive Cicero, since he knew well enough, that so long as he lived, he himself could never be in safety. And, lastly, an argument might also be fetched from the nature of the thing itself, in the following manner: That Cicero by this action would shamefully betray the state, and the cause of liberty, which he had through his whole life most courageously defended, with so great honour to himself, and advantage to the public. Upon such an account, a person might have used these or the like arguments with Cicero, which arise from the fore-mentioned heads.

From this account of common places, it is easy to conceive what a large field of discourse they open to the mind upon every subject. At the same time, though we have mentioned them from our respect for the orators of Greece and Rome, we heartily subscribe to the opinion of a celebrated modern, who gives of them the following account.

"The Grecian sophists were the first inventors of this artificial system of Oratory; and they showed a prodigious subtilty and fertility in the contrivance of these loci. Succeeding rhetoricians, dazzled by the plan, wrought them into so regular a system, that one would think they meant to teach how a person might mechanically become an orator, without any genius at all. They gave him receipts for making speeches on all manner of subjects. At the same time, it is evident, that though this study of common places might produce very showy academical declamations, it could never produce useful discourses on real business. The loci indeed supplied a most exuberant fecundity of matter. One who had no other aim, but to talk copiously and plausibly, by consulting them on every subject, and laying hold of all that they suggested, might discourse without end; and that, too, though he had none but the most superficial knowledge of his subject. But such discourse could be no other than trivial. What is truly solid and persuasive, must be drawn *ex visceribus causæ*, from a thorough knowledge of the subject, and profound meditation on it. They who

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11
The manner of reasoning from these heads.

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They are of no solid utility unless there is a previous foundation of learning and genius.

Blair's Lectures.

¹² *Invention.* who would direct students of oratory to any other sources of argumentation, only delude them; and by attempting to render rhetoric too perfect an art, they render it, in truth, a trifling and childish study."

¹³ *Of external topics, generally called testimonies.* II. *Of external topics.* When the orator reasons from such topics as do not arise from his subject, but from things of a different nature, these are called *external*. They are all taken from authorities, and are by one general name called *Testimonies*.

Now a testimony may be expressed by writing, speech, or any other sign proper to declare a person's mind. And all testimonies may be distinguished into two sorts, divine and human. A divine testimony, when certainly known to be such, is incontestable, and admits of no debate, but should be acquiesced in without hesitation. Indeed the ancient Greeks and Romans esteemed the pretended oracles of their deities, the answers of their augurs, and the like fallacies, divine testimonies: but with us no one can be ignorant of their true notion, though they do not so directly come under our present consideration. Human testimonies, considered as furnishing the orator with arguments, may be reduced to three heads; *writings, witnesses, and contracts*.

¹⁴ *Reduced to three heads, and separately explained.* I. By *Writings*, here, are to be understood written laws, wills, or other legal instruments, expressed and conveyed in that manner. And it is not so much the force and validity of such testimonies, considered in themselves, that is here intended, as the occasion of dispute which may at any time arise concerning their true design and import, when produced in proof upon either side of a controversy. And these are five; Ambiguity, Disagreement between the words and intention, Contrariety, Reasoning, and Interpretation.

A writing is then said to be ambiguous, when it is capable of two or more senses, which makes the writer's design uncertain. Now ambiguity may arise either from single words, or the construction of sentences. From single words; as when either the sense of a word, or the application of it, is doubtful. As, should it be questioned, whether ready money ought to be included under the appellation of chattels left by a will; or, if a testator bequeath a certain legacy to his nephew Thomas, and he has two nephews of that name. But ambiguity is also sometimes occasioned from the construction of a sentence; as when several things or persons having been already mentioned, it is doubtful to which of them that which follows ought to be referred. For example, a person writes thus in his will: "Let my heir give as a legacy to Titius an horse out of my stable, which he pleases." Here it may be questioned, whether the word *he* refers to the heir or to Titius; and consequently, whether the heir be allowed to give Titius which horse he pleases, or Titius may choose which he likes best. Now as to controversies of this kind, in the first case above-mentioned, the party who claims the chattels may plead, that all moveable goods come under that name, and therefore that he has a right to the money. This he will endeavour to prove from some instances where the word has been so used. The business of the opposite party is to refute this, by showing that money is not there included. And if either side produce precedents in his favour, the other may endeavour to show that the cases are not parallel. As to the second case,

arising from an ambiguity in the name, if any other words or expressions in the will seem to countenance either of the claimants, he will not fail to interpret them to his advantage. So likewise, if any thing said by the testator, in his lifetime, or any regard shown to either of these nephews more than the other, may help to determine which of them was intended, a proper use may be made of it. And the same may be said with regard to the third case. In which the legatee may reason likewise from the common use of language, and show that in such expressions it is usual to make the reference to the last or next antecedent; and from thence plead, that it was the design of the testator to give him the option. But in answer to this, it may be said, that allowing it to be very often so, yet in this instance it seems more easy and natural to repeat the verb *give* after *pleases*, and so to supply the sentence, *which he pleases to give him*, referring it to the heir, than to bring in the verb *choose*, which was not in the sentence before; and so, by supplying the sense, *which he pleases to choose*, to give the option to Titius. But where controversies of this kind arise from a law, recourse may be had to other laws where the same thing has been expressed with greater clearness; which may help to determine the sense of the passage in dispute.

A second controversy from writings is, when one party adheres to the words, and the other to what he asserts was the writer's intention. Now he who opposes the literal sense, either contends, that what he himself offers is the simple and plain meaning of the writing, or that it must be so understood in the particular case in dispute. An instance of the former is this, as we find it in Cicero. A person who died without children, but left a widow, had made this provision in his will: "If I have a son born to me, he shall be my heir." And a little after: "If my son die before he comes of age, let Curius be my heir." There is no son born: Curius therefore sues for the estate, and pleads the intention of the testator, who designed him for his heir, if he should have no son who arrived at age; and says, there can be no reason to suppose he did not intend the same person for his heir if he had no son, as if he should have one who afterwards died in his minority. But the heir at law insists upon the words of the will; which, as he says, require, that first a son should be born, and afterwards die under age, before Curius can succeed to the inheritance; and there being no son, a substituted heir, as Curius was, can have no claim where the first heir does not exist, from whom he derives his pretension, and was to succeed by the appointment of the will.—Of the latter case, rhetoricians give this example: "It was forbidden by a law to open the city-gates in the night. A certain person notwithstanding, in time of war, did open them in the night, and let in some auxiliary troops, to prevent their being cut off by the enemy, who was posted near the town." Afterwards, when the war was over, this person is arraigned, and tried for his life on account of this action. Now, in such a case, the prosecutor founds his charge upon the express words of the law; and pleads, that no sufficient reason can be assigned for going contrary to the letter of it, which would be to make a new law, and not to execute one already made. The defendant, on the other hand, alleges, That the fact he is charged

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with cannot, however, come within the intention of the law; since he either could not, or ought not, to have complied with the letter of it in that particular case, which must therefore necessarily be supposed to have been excepted in the design of that law when it was made. But to this the prosecutor may reply, That all such exceptions as are intended by any law, are usually expressed in it: and instances may be brought of particular exceptions expressed in some laws; and if there be any such exception in the law under debate, it should especially be mentioned. He may further add, That to admit of exceptions not expressed in the law itself, is to enervate the force of all laws, by explaining them away, and in effect to render them useless. And this he may further corroborate, by comparing the law under debate with others, and considering its nature and importance, and how far the public interest of the state is concerned in the due and regular execution of it; from whence he may infer, that should exceptions be admitted in other laws of less consequence, yet, however, they ought not in this. Lastly, he may consider the reason alleged by the defendant, on which he founds his plea, and show there was not that necessity of violating the law in the present case, as is pretended. And this is often the more requisite, because the party who disputes against the words of the law, always endeavours to support his allegations from the equity of the case. If, therefore, this plea can be enervated, the main support of the defendant's cause is removed. For as the former arguments are designed to prevail with the judge, to determine the matter on this side the question from the nature of the case; so the intention of this argument is to induce him to it, from the weakness of the defence made by the opposite party. But the defendant will, on the contrary, use such arguments as may best demonstrate the equity of his cause, and endeavour to vindicate the fact from his good design and intention in doing it. He will say, That the laws have allotted punishments for the commission of such facts as are evil in themselves, or prejudicial to others; neither of which can be charged upon the action for which he is accused: That no law can be rightly executed, if more regard be had to the words and syllables of the writing, than to the intention of the legislator. To which purpose, he may allege that direction of the law itself, which says, "The law ought not to be too rigorously interpreted, nor the words of it strained; but the true intention and design of each part of it duly considered." As also that saying of Cicero, "What law may not be weakened and destroyed, if we bend the sense to the words, and do not regard the design and view of the legislator?" Hence he may take occasion to complain of the hardship of such a procedure, that no difference should be made between an audacious and wilful crime, and an honest or necessary action, which might happen to disagree with the letter of the law, though not with the intent of it. And as it was observed before to be of considerable service to the accuser, if he could remove the defendant's plea of equity; so it will be of equal advantage to the defendant, if he can fix upon any words in the law, which may in the least seem to countenance his case, since this will take off the main force of the charge.

The third controversy of this kind is, when two writings happen to clash with each other, or at least

seem to do so. Of this Hermogenes gives the following instance. One law enjoins: "He who continues alone in a ship during a tempest, shall have the property of the ship." Another law says, "A disinherited son shall enjoy no part of his father's estate." Now a son, who had been disinherited by his father, happens to be in his father's ship in a tempest, and continues there alone, when every one else had deserted it. He claims the ship by the former of these laws, and his brother tries his right with him by the latter. In such cases, therefore, it may first be considered, "Whether the two laws can be reconciled. And if that cannot be done, then, Which of them appears more equitable. Also, Whether one be positive, and the other negative: because prohibitions are a sort of exceptions to positive injunctions. Or, If one be a general law, and the other more particular, and come nearer to the matter in question. Likewise, Which was last made: since former laws are often abrogated, either wholly or in part, by subsequent laws; or at least were designed to be so. Lastly, it may be observed, Whether one of the laws be not plain and express; and the other more dubious, or has any ambiguity in it. All, or any of which things, that party will not omit to improve for his advantage whose interest is concerned in it.

The fourth controversy is *reasoning*. As when something, not expressly provided for by a law, is inferred by a similitude, or parity of reason, from what is contained in it. Quintilian mentions this instance of it. "There was a law made at Tarentum, to prohibit the exportation of wool; but a certain person exports sheep." In this case, the prosecutor may first compare the thing which occasions the charge, with the words of the law, and show their agreement, and how unnecessary it was that particular thing should have been expressly mentioned in the law, since it is plainly contained in it, or at least an evident consequence from it. He may then plead, that many things of a like nature are omitted in other laws for the same reason. And, lastly, he may urge the reasonableness and equity of the procedure. The defendant, on the other hand, will endeavour to show the deficiency of the reasoning, and the difference between the two cases. He will insist upon the plain and express words of the law, and set forth the ill tendency of such inferences and conclusions drawn from similitudes and comparisons, since there is scarce any thing but in some respect may bear a resemblance to another.

The last controversy under this head is *interpretation*, in which the dispute turns upon the true meaning and explication of the law in reference to that particular case. We have the following instance of this in the Pandects: "A man who had two sons, both under age, substitutes Titius as heir to him who should die last, provided both of them died in their minority. They both perish together at sea before they came to age. Here arises a doubt, whether the substitution can take place, or whether the inheritance devolves to the heir at law." The latter pleads, That as neither of them can be said to have died last, the substitution cannot take place; which was suspended, upon the condition that one died after the other. But to this it may be said, It was the intention of the testator, that if both died in their nonage, Titius should

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Invention. should succeed to the inheritance; and therefore it makes no difference whether they died together, or one after the other: and so the law determines it.

2. The *second* head of external arguments are *Witnesses*. These may either give their evidence, when absent, in writing subscribed with their name; or present, by word of mouth. And what both of them testify, may either be from hearsay; or what they saw themselves, and were present at the time it was done. As the weight of the evidence may be thought greater or less on each of these accounts, either party will make such use of it as he finds for his advantage. The characters of the witnesses are also to be considered; and if any thing be found in their lives or behaviour that is justly exceptionable, to invalidate their evidence, it ought not to be omitted. And how they are affected to the contending parties, or either of them, may deserve consideration; for some allowances may be judged reasonable in case of friendship, or enmity, where there is no room for any other exception. But regard should chiefly be had to what they testify, and how far the cause is affected by it. Cicero is very large upon most of these heads in his defence of Marcus Fonteius, with a design to weaken the evidence of the Gauls against him. And where witnesses are produced on one side only, as orators sometimes attempt to lessen the credit of this kind of proof, by pleading that witnesses are liable to be corrupted, or biased by some prevailing interest or passion, to which arguments taken from the nature and circumstances of things are not subject; it may be answered on the other hand, that sophistical arguments and false colourings are not exposed to infamy or punishment, whereas witnesses are restrained by shame and penalties, nor would the law require them if they were not necessary.

3. The *third* and last head of external arguments are *Contracts*; which may be either public or private. By public are meant the transactions between different states, as leagues, alliances, and the like; which depend on the laws of nations, and come more properly under deliberative discourses, to which we shall refer them. Those are called *private*, which relate to lesser bodies or societies of men, and single persons; and may be either written or verbal. And it is not so much the true meaning and purport of them that is here considered, as their force and obligation. And, as the Roman law declares, "Nothing can be more agreeable to human faith, than that persons should stand to their agreements." Therefore, in controversies of this kind, the party whose interest it is that the contract should be maintained, will plead, that such covenants have the force of private laws, and ought religiously to be observed, since the common affairs of mankind are transacted in that manner; and therefore to violate them, is to destroy all commerce and society among men. On the other side it may be said, that justice and equity are chiefly to be regarded, which are immutable; and besides, that the public laws are the common rule to determine such differences, which are designed to redress those who are aggrieved. And, indeed, where a compact has been obtained by force or fraud, it is in itself void, and has no effect either in law or reason. But on the other hand, the Roman lawyers seem to have very rightly determined, that all such obligations as are founded on natural equity,

though not binding by national laws, and are therefore Invention. called *nuda pacta*, ought, however, in honour and conscience to be performed.

III. *Of the State of a Controversy.* The ancients, ¹⁵ Of the state observing that the principal question or point of dispute in all controversies might be referred to some particular head, reduced those heads to a certain number, ^{of a controversy, or the manner of referring the principal question in dispute to some particular head for greater ease of argument.} that both the nature of the question might by that means be better known, and the arguments suited to it be discovered with greater ease. And these heads they call *states*.

By the state of a controversy, then, we are to understand the principal point in dispute between contending parties, upon the proof of which the whole cause or controversy depends. We find it expressed by several other names in ancient writers: as, the *constitution of the cause*, the *general head*, and the *chief question*. And as this is the principal thing to be attended to in every such discourse; so it is what first requires the consideration of the speaker, and should be well fixed and digested in his mind, before he proceeds to look for arguments proper to support it. Thus Anthony, the Roman orator, speaking of his own method in his pleading, says: "When I understand the nature of the cause, and begin to consider it, the first thing I endeavour to do is, to settle with myself what that is to which all my discourse relating to the matter in dispute ought to be referred: then I diligently attend to these other two things, How to recommend myself, or those for whom I plead, to the good esteem of my hearers; and how to influence their minds, as may best suit my design." This way of proceeding appears very agreeable to reason and prudence. For what can be more absurd, than for a person to attempt the proof of any thing, before he has well settled in his own mind a clear and distinct notion what the thing is which he would endeavour to prove? Quintilian describes it to be, "That kind of question which arises from the first conflict of causes." In judicial cases, it immediately follows upon the charge of the plaintiff, and plea of the defendant. Our common law expresses it by one word, namely the *issue*. Which interpreters explain, by describing it to be, "That point of matter depending in suit, whereupon the parties join, and put their cause to the trial." Examples will further help to illustrate this, and render it more evident. In the cause of Milo, the charge of the Clodian party is, *Milo killed Clodius*. Milo's plea or defence, *I killed him, but justly*. From hence arises this grand question, or state of the cause, *Whether it was lawful for Milo to kill Clodius?* And that Clodius was lawfully killed by Milo, is what Cicero in his defence of Milo principally endeavours to prove. This is the main subject of that fine and beautiful oration. The whole of his discourse is to be considered as centering at last in this one point. Whatever different matters are occasionally mentioned, will, if closely attended to, be found to have been introduced some way or other the better to support and carry on this design. Now in such cases, where the fact is not denied, but something is offered in its defence, the state of the cause is taken from the defendant's plea, who is obliged to make it good: As in the instance here given, the chief point in dispute was the lawfulness of Milo's action, which it was Cicero's business to demonstrate.

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But when the defendant denies the fact, the state of the cause arises from the accusation; the proof of which then lies upon the plaintiff, and not, as in the former case, upon the defendant. So in the cause of Roscius, the charge made against him is, *That he killed his father*. But he denies the fact. The grand question therefore to be argued is, *Whether or not he killed his father?* The proof of this lay upon his accusers. And Cicero's design in his defence of him is to show, that they had not made good their charge. But it sometimes happens, that the defendant neither absolutely denies the fact, nor attempts to justify it; but only endeavours to qualify it, by denying that it is a crime of that nature, or deserves that name, by which it is expressed in the charge. We have an example of this proposed by Cicero: "A person is accused of sacrilege, for taking a thing, that was sacred, out of a private house. He owns the fact, but denies it to be sacrilege; since it was committed in a private house, and not in a temple." Hence this question arises, *Whether to take a sacred thing out of a private house, is to be deemed sacrilege, or only simple theft?* It lies upon the accuser to prove what the other denies; and therefore the state of the cause is here also, as well as in the preceding case, taken from the indictment.

But besides the principal question, there are other subordinate questions, which follow upon it in the course of a dispute, and should be carefully distinguished from it. Particularly that which arises from the reason, or argument, which is brought in proof of the principal question. For the principal question itself proves nothing, but is the thing to be proved, and becomes at last the conclusion of the discourse. Thus, in the cause of Milo, his argument is, *I killed Clodius justly, because he assassinated me*. Unless the Clodian party be supposed to deny this, they give up their cause. From hence therefore this subordinate question follows, *Whether Clodius assassinated Milo?* Now Cicero spends much time in the proof of this, as the hinge on which the first question, and consequently the whole cause, depended. For if this was once made to appear, the lawfulness of Milo's killing Clodius, which was the grand question or thing to be proved, might be inferred as an allowed consequence from it. This will be evident, by throwing Milo's argument, as used by Cicero, into the form of a syllogism.

An assassin is lawfully killed:

Clodius was an assassin:

Therefore he was lawfully killed by Milo, whom he assassinated.

If the minor proposition of this syllogism was granted, no one would deny the conclusion: for the Roman law allowed of self-defence. But as Cicero was very sensible this would not be admitted, so he takes much pains to bring the court into the belief of it. Now where the argument brought in defence of the second question is contested, or the orator supposes that it may be so, and therefore supports that with another argument, this occasions a third question consequent upon the former; and in like manner he may proceed to a fourth. But be they more or fewer, they are to be considered but as one chain of subordinate questions

dependent upon the first. And though each of them has its particular state, yet none of these is what rhetoricians call *The state of the Cause*, which is to be understood only of the principal question. And if, as it frequently happens, the first or principal question is itself directly proved from more than one argument; this makes no other difference, but that each of these arguments, so far as they are followed by others to support them, become a distinct series of subordinate questions, all dependent upon the first. As when Cicero endeavours to prove, that Roscius did not kill his father, from two reasons or arguments: *Because he had neither any cause to move him to such a barbarous action, nor any opportunity for it.*

Moreover, besides these subordinate questions, there are also incidental ones often introduced, which have some reference to the principal question, and contribute towards the proof of it, though they are not necessarily connected with it, or dependent upon it. And each of these also has its state, though different from that of the cause. For every question, or point of controversy, must be stated, before it can be made the subject of disputation. And it is for this reason, that every new argument advanced by an orator is called a *question*; because it is considered as a fresh matter of controversy. In Cicero's defence of Milo, we meet with several of this sort of questions, occasioned by some aspersions which had been thrown out by the Clodian party to the prejudice of Milo. As, "That he was unworthy to see the light, who owned he had killed a man:" For Milo before his trial had openly confessed he killed Clodius. So likewise, "That the senate had declared the killing of Clodius was an illegal action." And further, "That Pompey, by making a new law to settle the manner of Milo's trial, had given his judgment against Milo." Now to each of these Cicero replies, before he proceeds to the principal question. And therefore, though the question, in which the state of a controversy consists, is said by Quintilian to arise from "the first conflict of causes," yet we find by this instance of Cicero, that it is not always the first question in order, upon which the orator treats.

But it sometimes happens, that the same cause or controversy contains in it more than one state. Thus in judicial causes, every distinct charge occasions a new state. All Cicero's orations against Verres relate to one cause, founded upon a law of the Romans against unjust exactions made by their governors of provinces upon the inhabitants; but as that prosecution is made up of as many charges as there are orations, every charge, or indictment, has its different state. So likewise his oration in defence of Coelius has two states, in answer to a double charge made against him by his adversaries: one, "for borrowing money of Clodia, in order to bribe certain slaves to kill a foreign ambassador;" and the other, "for an attempt afterward to poison Clodia herself." Besides which, there were several other matters of a less heinous nature, which had been thrown upon him by his accusers, with a design, very likely, to render the two principal charges more credible; to which Cicero first replies, in the same manner as in his defence of Milo.

Though all the examples we have hitherto brought to illustrate this subject have been taken from judicial cases;

Invention. cases; yet not only these, but very frequently discourses of the deliberative kind, and sometimes those of the demonstrative, are managed in a controversial way. And all controversies have their state. And therefore Quintilian very justly observes, that "states belong both to general and particular questions; and to all sorts of causes, demonstrative, deliberative, and judicial." In Cicero's oration for the Manilian law, this is the main point in dispute between him and those who opposed that law: "Whether Pompey was the fittest person to be intrusted with the management of the war against Mithridates?" This is a subject of the deliberative kind. And of the same nature was that debate in the senate concerning the demolition of Carthage. For the matter in dispute between Cato, who argued for it, and those who were of the contrary opinion, seems to have been this: "Whether it was for the interest of the Romans to demolish Carthage?" And so likewise in those two fine orations of Cato and Cæsar, given us by Sallust, relating to the conspirators with Catiline, who were then in custody, the controversy turns upon this: "Whether those prisoners should be punished with death, or perpetual imprisonment?" Examples of the demonstrative kind are not so common; but Cicero's oration concerning the 'Answers of the soothsayers,' may afford us an instance of it. Several prodigies had lately happened at Rome; upon which the soothsayers being consulted, assigned this as the reason of them, Because some places consecrated to the gods had been afterwards converted to civil uses. Clodius charged this upon Cicero; whose house was rebuilt at the public expence, after it had been demolished by Clodius, and the ground consecrated to the goddess Liberty. Cicero in this oration retorts the charge; and shows that the prodigies did not respect him, but Clodius. So that the question in dispute was, "To which of the two those prodigies related?" This oration does not appear to have been spoken in a judicial way, and must therefore belong to the demonstrative kind. His invective against Piso is likewise much of the same nature, wherein he compares his own behaviour and conduct with that of Piso.

As to the number of these states, both Cicero and Quintilian reduce them to three. "We must (says Quintilian) agree with those, whose authority Cicero follows, who tells us, that three things may be inquired into in all disputes: Whether a thing is; what it is; and how it is. And this is the method which nature prescribes. For in the first place, it is necessary the thing should exist about which the dispute is: because no judgment can be made either of its nature or quality till its existence be manifest; which is therefore the first question. But though it be manifest that a thing is, it does not presently appear what it is; and when this is known, the quality yet remains: and after these three are settled, no further inquiry is necessary." Now the first of these three states is called the *conjunctural state*; as if it be inquired, "Whether one person killed another?" This always follows upon the denial of a fact, by one of the parties; as was the case of Roscius. And it receives its name from hence, that the judge is left, as it were, to conjecture, whether the fact was really committed or not, from the evidence produced on the other side. The second is call-

Invention. ed the *definitive state*, when the fact is not denied; but the dispute turns upon the nature of it, and what name it is proper to give it: as in that example of Cicero, "Whether to take a sacred thing out of a private house be theft, or sacrilege?" For in this case it is necessary to settle the distinct notion of those two crimes, and show their difference. The third is called the *state of quality*; when the contending parties are agreed both as to the fact, and the nature of it; but the dispute is, "Whether it be just or unjust, profitable or unprofitable, and the like;" as in the cause of Milo.

From what has been said upon this subject, the use of it may in a good measure appear. For whoever engages in a controversy, ought in the first place to consider with himself the main question in dispute, to fix it well in his mind, and keep it constantly in his view; without which he will be very liable to ramble from the point, and bewilder both himself and his hearers. And it is no less the business of the hearers principally to attend to this; by which means they will be helped to distinguish and separate from the principal question what is only incidental, and to observe how far the principal question is affected by it; to perceive what is offered in proof, and what is only brought in for illustration; not to be misled by digressions, but to discern when the speaker goes off from his subject, and when he returns to it again; and, in a word, to accompany him through the whole discourse, and carry with them the principal chain of reasoning upon which the cause depends, so as to judge upon the whole, whether he has made out his point, and the conclusion follows from the premises.

CHAP. II. Of Arguments suited to Demonstrative Discourses.

THESE consist either in praise or dispraise; and, agreeably to the nature of all contraries, one of them will serve to illustrate the other.

Now we either praise *persons* or *things*.

1. In praising or dispraising *persons*, rhetoricians prescribe two methods. One is, to follow the order in which every thing happened that is mentioned in the discourse; the other is, to reduce what is said under certain general heads, without a strict regard to the order of time.

1. In pursuing the former method, the discourse may be very conveniently divided into three periods. The first of which will contain what preceded the person's birth; the second, the whole course of his life; and the third what followed upon his death.

Under the first of these may be comprehended what is proper to be said concerning his country or family. And therefore, if these were honourable, it may be said to his advantage, that he nowise disgraced them, but acted suitably to such a descent. But if they were not so, they may be either wholly omitted; or it may be said, that, instead of deriving thence any advantage to his character, he has conferred a lasting honour upon them; and that it is not of so much moment where, or from whom, a person derives his birth, as how he lives.

In the second period, which is that of his life, the qualities both of his mind and body, with his circumstances in the world, may be separately considered.

Invention. Though, as Quintilian rightly observes, "All external advantages are not praises for themselves, but according to the use that is made of them. For riches, and power, and interest; as they have great influence, and may be applied either to good or bad purposes, are a proof of the temper of our minds; and therefore we are either made better or worse by them." But these things are a just ground for commendation, when they are the reward of virtue or industry. Bodily endowments are health, strength, beauty, activity, and the like; which are more or less commendable, according as they are employed. And where these, or any of them, are wanting, it may be shown, that they are abundantly compensated by the more valuable endowments of the mind. Nay, sometimes a defect in these may give an advantageous turn to a person's character; for any virtue appears greater, in proportion to the disadvantages the person laboured under in exerting it. But the chief topics of praise are taken from the virtues and qualifications of the mind. And here the orator may consider the disposition, education, learning, and several virtues, which shone through the whole course of the person's life. In doing which, the preference should always be given to virtue above knowledge or any other accomplishment. And in actions, those are most considerable, and will be heard with greatest approbation, which a person either did alone, or first, or wherein he had fewest associates; as likewise those which exceeded expectation, or were done for the advantage of others rather than his own. And further, as the last scene of a man's life generally commands the greatest regard, if any thing remarkable at that time was either said or done, it ought particularly to be mentioned. Nor should the manner of his death, or cause of it, if accompanied with any commendable circumstances, be omitted; as if he died in the service of his country, or in the pursuit of any other laudable design.

The third and last period relates to what followed after the death of the person. And here the public loss, and public honours conferred upon the deceased, are proper to be mentioned. Sepulchres, statues, and other monuments to perpetuate the memory of the dead, at the expence of the public, were in common use both among the Greeks and Romans. But in the earliest times, as these honours were more rare, so they were less costly. For as in one age it was thought a sufficient reward for him who died in the defence of his country, to have his name cut in a marble inscription, with the cause of his death; so in others it was very common to see the statues of gladiators, and persons of the meanest rank, erected in public places. And therefore a judgment is to be formed of these things from the time, custom, and circumstances, of different nations; since the frequency of them renders them less honourable, and takes off from their evidence as the rewards of virtue. But, as Quintilian says, "Children are an honour to their parents, cities to their founders, laws to those who compiled them, arts to their inventors, and useful customs to the authors of them."

And this may suffice for the method of praising persons, when we propose to follow the order of time, as Isocrates has done in his funeral oration upon Evagoras king of Salamis, and Pliny in his panegyric

upon the emperor Trajan. But as this method is very plain and obvious, so it requires the more agreeable dress to render it delightful; lest otherwise it seem rather like an history than an oration: For which reason, we find, that epic poets, as Homer, Virgil, and others, begin with the middle of their story, and afterwards take a proper occasion to introduce what preceded, to diversify the subject, and give the greater pleasure and entertainment to their readers.

2. The other method above hinted was, to reduce the discourse to certain general heads without regarding the order of time. As if any one, in praising the elder Cato, should propose to do it, by showing that he was a most prudent senator, an excellent orator, and most valiant general; all which commendations are given him by Pliny. In like manner, the character of a good general may be comprised under four heads; skill in military affairs, courage, authority, and success: from all which Cicero commends Pompey. And agreeably to this method Suetonius has written the lives of the first twelve Cæsars.

But in the praising of persons, care should always be taken to say nothing that may seem fictitious or out of character, which may call the orator's judgment or integrity in question. It was not without cause, therefore, that Lysippus the statuary, as Plutarch tells us, blamed Apelles for painting Alexander the Great with thunder in his hand; which could never suit his character as a man, however he might boast of his divine descent: for which reason Lysippus himself made an image of him holding a spear, as the sign of a warrior. Light and trivial things in commendations are likewise to be avoided, and nothing mentioned but what may carry in it the idea of something truly valuable, and which the hearers may be supposed to wish for, and is proper to excite their emulation. These are the principal heads of praise with relation to men. In dispraise, the heads contrary to these are requisite; which being sufficiently clear from what has been said, need not particularly be insisted on.

II. We proceed therefore to the other part of the division, which respects *things*, as distinguished from persons. By which we are to understand all beings inferior to man, whether animate or inanimate; as likewise the habits and dispositions of men, either good or bad, when considered separately, and apart from their subjects, as arts and sciences, virtues and vices, with whatever else may be a proper subject for praise or dispraise. Some writers, indeed, have, for their own amusement and the diversion of others, displayed their eloquence in a jocular manner upon subjects of this kind. So Lucian has written in praise of a fly, and Synesius an elegant encomium upon baldness. Others, on the contrary, have done the like in a satirical way. Such is Seneca's apotheosis or consecration of the emperor Claudius; and the Mysopogon or beard-hater, written by Julian the emperor. Not to mention several modern authors, who have imitated them in such ludicrous compositions. But as to these things, and all of the like nature, the observation of Antony in Cicero seems very just: "That it is not necessary to reduce every subject we discourse upon to rules of art." For many are so trivial, as not to deserve it; and others so plain and evident of themselves,

as

Invention. as not to require it. But since it frequently comes in the way both of orators and historians to describe countries, cities, and facts, we shall briefly mention the principal heads of invention proper to illustrate each of these.

Countries, then, may be celebrated from the pleasantness of their situation, the clemency and wholesomeness of the air, and goodness of the soil; to which last may be referred the springs, rivers, woods, plains, mountains, and minerals. And to all these may be added their extent, cities, the number and antiquity of the inhabitants; their policy, laws, customs, wealth, character for cultivating the arts both of peace and war; their princes, and other eminent men they have produced. Thus Pacatus has given us a very elegant description of Spain, in his panegyric upon the emperor Theodosius, who was born there.

Cities are praised from much the same topics as countries. And here, whatever contributes either to their defence or ornament ought particularly to be mentioned; as the strength of the walls and fortifications, the beauty and splendor of the buildings, whether sacred or civil, public or private. We have in Herodotus a very fine description of Babylon, which was once the strongest, largest, and most regular city in the world. And Cicero has accurately described the city of Syracuse, in the island Sicily, in one of his orations against Verres.

But facts come much oftener under the cognizance of an orator. And these receive their commendation from their honour, justice, or advantage. But in describing them, all the circumstances should be related in their proper order; and that in the most lively and affecting manner, suited to their different nature. Livy has represented the demolition of Alba by the Roman army, which was sent thither to destroy it, thro' the whole course of that melancholy scene, in a style so moving and pathetic, that one can hardly forbear condoling with the inhabitants, upon reading his account.

But in discourses of this kind, whether of praise or dispraise, the orator should (as he ought indeed upon all occasions) well consider where, and to whom, he speaks. For wise men often think very differently both of persons and things from the common people. And we find that learned and judicious men are frequently divided in their sentiments, from the several ways of thinking to which they have been accustomed. Besides, different opinions prevail, and gain the ascendant, at different times. While the Romans continued a free nation, love of their country, liberty, and public spirit, were principles in the highest esteem among them. And therefore, when Cato killed himself, that he might not fall into the hands of Cæsar, and survive the liberty of his country, it was thought an instance of the greatest heroic virtue; but afterwards, when they had been accustomed to an arbitrary government, and the spirit of liberty was now lost, the poet Marcial could venture to say,

Death to avoid 'tis madness sure to die.

A prudent orator therefore will be cautious of opposing any settled and prevailing notions of those to whom he addresses; unless it be necessary, and then he will do it in the softest and most gentle manner.

CHAP. III. Of Arguments suited to Deliberative Discourses.

Invention. ¹⁷ Of deliberative discourses, and the arguments suited to them. THIS kind of discourses must certainly have been very ancient; since, doubtless, from the first beginning of mens conversing together, they deliberated upon their common interest, and offered their advice to each other. But neither those of the laudatory nor judicial kind could have been introduced, till mankind were settled in communities, and found it necessary to encourage virtue by public rewards, and bring vice under the restraint of laws. The early practice of suasive discourses appears from sacred writ, where we find, that when Moses was ordered upon an embassy into Egypt, he would have excused himself for want of eloquence. And Homer represents the Greeks at the siege of Troy, as flocking like a swarm of bees to hear their generals harangue them. Nor is this part of oratory less conspicuous for its usefulness to mankind, than for its antiquity; being highly beneficial either in councils, camps, or any societies of men. How many instances have we upon record, where the fury of an enraged multitude has been checked and appeased by the prudent and artful persuasion of some particular person? The story of Agrippa Menenius, when the commons of Rome withdrew from the senators, and retired out of the city, is too well known to need reciting. And how often have armies been animated and fired to the most dangerous exploits, or recalled to their duty, when ready to mutiny, by a moving speech of their general? many instances of which we find in history.

All deliberation respects something future, for it is in vain to consult about what is already past. The subject-matter of it is, either things public or private, sacred or civil; indeed all the valuable concerns of mankind, both present and future, come under its regard. And the end proposed by this kind of discourses is chiefly profit or interest. But since nothing is truly profitable, but what is in some respect good; and every thing which is good in itself may not in all circumstances be for our advantage; properly speaking, what is both good and profitable, or beneficial good, is the end here designed. And therefore, as it sometimes happens, that what appears profitable may seem to interfere with that which is strictly just and honourable; in such cases it is certainly most advisable to determine on the safer side of honour and justice, notwithstanding some plausible things may be offered to the contrary. But where the dispute lies apparently between what is truly honest, and some external advantage proposed in opposition to it, all good men cannot but agree in favour of honesty. Such was the case of Regulus, who, being taken prisoner by the Carthaginians, was permitted to go to Rome upon giving his oath, that unless he could persuade the senate to set at liberty some young Carthaginian noblemen, then prisoners at Rome, in exchange for him, he should return again to Carthage. But Regulus, when he came to Rome, was so far from endeavouring to prevail with the senate to comply with the desire of the Carthaginians, that he used all his interest to dissuade them from hearkening to the proposal. Nor could the most earnest intreaties of his nearest relations and friends, nor any arguments they were able to offer, engage him to continue at Rome, and not return again

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to Carthage. He had then plainly in his view, on the one side, ease, security, affluence, honours, and the enjoyment of his friends; and on the other, certain death, attended with cruel torments. However, thinking the former not consistent with truth and justice, he chose the latter. And he certainly acted as became an honest and brave man, in choosing death, rather than to violate his oath. Though whether he did prudently in persuading the senate not to make the exchange, or they in complying with him, we shall leave others to determine. Now, when it proves to be a matter of debate, whether a thing upon the whole be really beneficial or not; as here arise two parts, advice and dissuasion, they will each require proper heads of argument. But as they are contrary to each other, he who is acquainted with one, cannot well be ignorant of the other. We shall therefore chiefly mention those proper for advice, from whence such as are suited to dissuade will easily be perceived. Now the principal heads of this kind are these following, which are taken from the nature and properties of the thing itself under consideration.

1. *Pleasure* often affords a very cogent argument in discourses of this nature. Every one knows what an influence this has upon the generality of mankind. Though, as Quintilian remarks, pleasure ought not of itself to be proposed as a fit motive for action in serious discourses, but when it is designed to recommend something useful, which is the case here. So, would any one advise another to the pursuit of polite literature, Cicero has furnished him with a very strong inducement to it from the pleasure which attends that study, when he says, "If pleasure only was proposed by these studies, you would think them an entertainment becoming a man of sense and a gentleman. For other pursuits neither agree with all times, all ages, nor all places; but these studies improve youth, delight old age, adorn prosperity, afford a refuge and comfort in adversity, divert us at home, are no hindrance abroad, sleep, travel, and retire with us into the country."

2. *Profit*, or advantage. This has no less influence upon many persons than the former; and when it respects things truly valuable, it is a very just and laudable motive. Thus Cicero, when he sends his *books of offices* to his son, which he wrote in Latin for his use, advises him to make the best advantage both of his tutor's instructions, and the conversation at Athens, where he then was; but withal to peruse his philosophical treatises, which would be doubly useful to him, not only upon account of the subjects, but likewise of the language, as they would enable him to express himself upon those arguments in Latin, which before had only been treated of in Greek.

3. *Honour*; than which no argument will sooner prevail with generous minds, or inspire them with greater ardour. Virgil has very beautifully described Hector's ghost appearing to Æneas the night Troy was taken, and advising him to depart, from this motive of honour:

O goddess-born, escape by timely flight
The flames and horrors of this fatal night.
The foes already have possess'd the wall;
Troy nods from high, and totters to her fall.
Nº 250.

Enough is paid to Priam's royal name;
More than enough to duty and to fame.
If by a mortal hand my father's throne
Cou'd be defended, 'twas by mine alone.

The argument here made use of to persuade Æneas to leave Troy immediately, is, that he had done all that could be expected from him, either as a good subject or brave soldier, both for his king and country; which were sufficient to secure his honour: and now there was nothing more to be expected from him when the city was falling, and impossible to be saved; which could it have been preserved by human power, he himself had done it.

But although a thing considered in itself appear beneficial if it could be attained, yet the expediency of undertaking it may still be questionable: in which case the following heads, taken from the circumstances which attend it, will afford proper arguments to engage in it.

(1.) The *possibility* of succeeding may sometimes be argued, as one motive to this end. So Hannibal endeavoured to convince king Antiochus, that it was possible for him to conquer the Romans, if he made Italy the seat of the war; by observing to him, not only that the Gauls had formerly destroyed their city, but that he had himself defeated them in every battle he fought with them in that country.

(2.) But an argument founded upon *probability* will be much more likely to prevail. For in many affairs of human life, men are determined either to prosecute them or not, as the prospect of success appears more or less probable. Hence Cicero, after the fatal battle at Pharsalia, dissuades those of Pompey's party, with whom he was engaged, from continuing the war any longer against Cæsar; because it was highly improbable, after such a defeat, by which their main strength was broken, that they should be able to stand their ground, or meet with better success than they had before.

(3.) But further, since probability is not a motive strong enough with many persons to engage in the prosecution of a thing which is attended with considerable difficulties, it is often necessary to represent the facility of doing it, as a further reason to induce them to it. And therefore Cicero makes use of this argument to encourage the Roman citizens in opposing Mark Anthony (who upon the death of Cæsar had assumed an arbitrary power), by representing to them, that his circumstances were then desperate, and that he might easily be vanquished.

(4.) Again, if the thing advised can be shown to be in any respect necessary, this will render the motive still much stronger for undertaking it. And therefore Cicero joins this argument with the former, to prevail with the Roman citizens to oppose Anthony, by telling them, that "The consideration before them was, not in what circumstances they should live, but whether they should live at all, or die with ignominy and disgrace." This way of reasoning will sometimes prevail when all others prove ineffectual. For some persons are not to be moved, till things are brought to an extremity, and they find themselves reduced to the utmost danger.

(5.) To these heads may be added the consideration

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tion of the *event*, which in some cases carries great weight with it. As when we advise to the doing of a thing from this motive, That whether it succeed or not, it will yet be of service to undertake it. So after the great victory gained by Themistocles over the Persian fleet at the straits of Salamis, Mardonius advised Xerxes to return into Asia himself, lest the report of his defeat should occasion an insurrection in his absence: but to leave behind him an army of 300,000 men under his command; with which, if he should conquer Greece, the chief glory of the conquest would redound to Xerxes; but if the design miscarried, the disgrace would fall upon his generals.

These are the principal heads which furnish the orator with proper arguments in giving advice. Cicero, in his oration for the Manilian law, where he endeavours to persuade the Roman people to choose Pompey for their general in the Mithridatic war, reasons from three of these topics, into which he divides his whole discourse; namely, the necessity of the war, the greatness of it, and the choice of a proper general. Under the first of these he shows, that the war was necessary, from four considerations; the honour of the Roman state, the safety of their allies, their own revenues, and the fortunes of many of their fellow-citizens, which were all highly concerned in it, and called upon them to put a stop to the growing power of king Mithridates, by which they were all greatly endangered. So that this argument is taken from the head of *necessity*. The second, in which he treats of the greatness of the war, is founded upon the topic of *possibility*. For though he shows the power of Mithridates to be very great, yet not so formidable, but that he might be subdued; as was evident from the many advantages Lucullus had gained over him and his associates. In the third head, he endeavours to prevail with them to intrust the management of the war in the hands of Pompey, whom he describes as a consummate general, for his skill in military affairs, courage, authority, and success; in all which qualities he represents him as superior to any other of their generals whom they could at that time make choice of. The design of all which was, to persuade them, that they had very good reason to hope for success, and a happy event of the war, under his conduct. So that the whole force of his reasoning under this head is drawn from *probability*. These are the three general topics which make up that fine discourse. Each of which is indeed supported by divers other arguments and considerations, which will be obvious in perusing the oration itself, and therefore need not be here enumerated. On the contrary, in another oration he endeavours to dissuade the senate from consenting to a peace with Mark Antony, because it was base, dangerous, and impracticable.

But no small skill and address are required in giving advice. For since the tempers and sentiments of mankind, as well as their circumstances, are very different and various; it is often necessary to accommodate the discourse to their inclinations and opinions of things. And therefore the weightiest arguments are not always the most proper and fittest to be used on all occasions. Cicero, who was an admirable master of this art, and knew perfectly well how to suit what he said

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to the taste and relish of his hearers, in treating upon this subject, distinguishes mankind into two sorts; the ignorant and unpolished, who always prefer profit to honour; and such as are more civilized and polite, who prefer honour and reputation to all other things. Wherefore they are to be moved by these different views: Praise, glory, and virtue, influence the one; while the other is only to be engaged by a prospect of gain and pleasure. Besides, it is plain, that the generality are much more inclined to avoid evils than to pursue what is good; and to keep clear of scandal and disgrace, than to practise what is truly generous and noble. Persons likewise of a different age act from different principles; young men for the most part view things in another light from those who are older and have had more experience, and consequently are not to be influenced by the same motives.

CHAP. IV. Of Arguments suited to Judicial Discourses.

IN *judicial* controversies there are two parties; the plaintiff or prosecutor, and the defendant or person charged. The subject of them is always something past. And the end proposed by them. Cicero calls *equity*, or *right and equity*; the former of which arises from the laws of the country, and the latter from reason and the nature of things. For at Rome the prætors had a court of equity, and were empowered, in many cases relating to property, to relax the rigour of the written laws. But as this subject is very copious, and causes may arise from a great variety of things, writers have reduced them to three heads, which they call *states*, to some one of which all judicial proceedings may be referred; namely, *whether a thing is, what it is, or how it is*. By the *state* of a cause therefore is meant the principal question in dispute, upon which the whole affair depends. Which, if it stops in the first inquiry, and the defendant denies the fact, the state is called *conjectural*; but if the fact be acknowledged, and yet denied to be what the adversary calls it, it is termed *definitive*; but if there is no dispute either about the fact or its name, but only the justice of it, it is called the *state of quality*: as was shown more largely before (see n° 15). But we there considered these states only in a general view, and deferred the particular heads of argument proper for each of them to this *judicial* kind of discourses; where they most frequently occur, and from which examples may easily be accommodated to other subjects.

All judicial causes are either *private* or *public*. Those are called *private*, which relate to the right of particular persons; and they are likewise called *civil* causes, as they are conversant about matters of property. *Public* causes are those which relate to public justice and the government of the state; which are also called *criminal*, because by them crimes are prosecuted, whether capital, or those of a less heinous nature. We shall take the heads of the arguments only from this latter kind, because they are more copious, and easy to be illustrated by examples; from which such as agree to the former, namely, *civil* causes, will sufficiently appear.

1. The *conjectural* state. When the accused person denies

Invention. denies the fact, there are three things which the prosecutor has to consider; whether he *would* have done it, whether he *could*, and whether he *did* it. And hence arise three topics; from the *will*, the *power*, and the *signs* or circumstances which attended the action. The affections of the mind discover the will; as, passion, an old grudge, a desire of revenge, a resentment of an injury, and the like. Therefore Cicero argues from Clodius's hatred of Milo, that he designed his death; and from thence infers, that he was the aggressor in the combat between them, wherein Clodius was killed. This is what he principally endeavours to prove, and comes properly under this state: for Milo owned that he killed him, but alleged that he did it in his own defence. So that in regard to this point, Which of them assaulted the other? the charge was mutual. The prospect of advantage may also be alleged to the same purpose. Hence it is said of L. Cassius, that whenever he sat as judge in a case of murder, he used to advise and move the court to examine to whom the advantage arose from the death of the deceased. And Cicero puts this to Anthony concerning the death of Cæsar. "If any one (says he) should bring you upon trial, and use that saying of Cassius, *Cui bono?* 'Who got by it?' look to it, I beseech you, that you are not confounded." To these arguments may be added, hope of impunity, taken either from the circumstances of the accused person, or of him who suffered the injury. For persons, who have the advantage of interest, friends, power, or money, are apt to think they may easily escape; as likewise such who have formerly committed other crimes with impunity. Thus Cicero represents Clodius as hardened in vice, and above all the restraint of laws, from having so often escaped punishment upon committing the highest crimes. On the contrary, such a confidence is sometimes raised from the condition of the injured party, if he is indigent, obscure, timorous, or destitute of friends; much more if he has an ill reputation, or is loaded with popular hatred and resentment. It was this presumption of the obscurity of Roscius, who lived in the country, and his want of interest at Rome, which encouraged his accusers to charge him with killing his father, as Cicero shows in his defence of him. Lastly, the temper of a person, his views, and manner of life, are considerations of great moment in this matter. For persons of bad morals, and such as are addicted to vice, are easily thought capable of committing any wickedness. Hence Sallust argues from the evil disposition and vicious life of Catiline, that he affected to raise himself upon the ruins of his country.—The second head is the *power* of doing a thing: and there are three things which relate to this, the *place*, the *time*, and *opportunity*. As if a crime is said to have been committed in a private place, where no other person was present; or in the night; or when the injured person was unable to provide for his defence. Under this head may likewise be brought in the circumstances of the persons; as if the accused person was stronger, and so able to overpower the other; or more active, and so could easily make his escape. Cicero makes great use of this topic in the case of Milo, and shows, that Clodius had all the advantages of *place*, *time*, and *opportunity*, to execute his de-

sign of killing him. The third head comprehends *Invention.* the *signs* and circumstances which either preceded, accompanied, or followed, the commission of the fact. So threats, or the accused person being seen at or near the place before the fact was committed, are circumstances that may probably precede murder; fighting, crying out, bloodshed, are such as accompany it; paleness, trembling, inconsistent answers, hesitation, or faltering of the speech, something found upon the person accused which belonged to the deceased, are such as follow it. Thus Cicero proves, that Clodius had threatened the death of Milo, and given out that he should not live above three days at the farthest.—These arguments, taken from conjectures, are called *presumptions*, which, though they do not directly prove that the accused person committed the fact with which he is charged; yet when laid together, they appeared very strong, sentence by the Roman law might sometimes be given upon them, to convict him.

These are the topics from which the prosecutor takes his arguments. Now the business of the defendant is to invalidate these. Therefore such as are brought from the *will*, he either endeavours to show are not true, or so weak as to merit very little regard. And he refutes those taken from the *power*, by proving that he wanted either opportunity or ability: as, if he can show, that neither the place nor time insisted on was at all proper; or that he was then in another place. In like manner he will endeavour to confute the *circumstances*, if they cannot be directly denied, by showing that they are not such as do necessarily accompany the fact, but might have proceeded from other causes, though nothing of what is alleged had been committed; and it will be of great service to assign some other probable cause. But sometimes the defendant does not only deny that he did the fact, but charges it upon another. Thus Cicero, in his oration for Roscius, not only defends him from each of these three heads, but likewise charges the fact upon his accusers.

2. The *definitive* state, which is principally concerned in defining and fixing the name proper to the fact: though orators seldom make use of exact definitions, but commonly choose larger descriptions, taken from various properties of the subject or thing described.

The heads of argument in this state are much the same to both parties. For each of them defines the fact his own way, and endeavours to refute the other's definition. We may illustrate this by an example from Quintilian: "A person is accused of sacrilege, for stealing money out of a temple, which belonged to a private person." The fact is owned; but the question is, *Whether it be properly sacrilege?* The prosecutor calls it so, because it was taken out of a temple. But since the money belonged to a private person, the defendant denies it to be sacrilege, and says it is only simple theft. Now the reason why the defendant uses this plea, and insists upon the distinction, is, because by the Roman law the penalty of theft was only four times the value of what was stolen; whereas sacrilege was punished with death. The prosecutor then forms his definition agreeable to his charge, and says, "To steal any thing out of a sacred place is sacrilege." But the defendant excepts against this definition,

Invention. definition, as defective; and urges, that it does not amount to sacrilege, unless the thing stolen was likewise sacred. And this case might once, perhaps, have been a matter of controversy, since we find it expressly determined in the Pandects, that "An action of sacrilege should not lie, but only of theft, against any one who should steal the goods of private persons deposited in a temple."

The second thing is the proof brought by each party to support his definition; as in the example given us by Cicero, of one "who carried his cause by bribery, and was afterwards prosecuted again upon an action of prevarication." Now, if the defendant was cast upon this action, he was, by the Roman law, subjected to the penalty of the former prosecution. Here the prosecutor defines prevarication to be, *Any bribery or corruption in the defendant, with a design to pervert justice.* The defendant, therefore, on the other hand, restrains it to *bribing only the prosecutor.*

And if this latter sense agrees better with the common acceptation of the word, the prosecutor in the third place pleads the intention of the law, which was to comprehend all bribery in judicial matters under the term of *prevarication*. In answer to which the defendant endeavours to show, either from the head of contraries, that a real prosecutor and a prevaricator are used as opposite terms in the law; or from the etymology of the word, that a prevaricator denotes one who pretends to appear in the prosecution of a cause, while in reality he favours the contrary side; and consequently, that money given for this end only can, in the sense of the law, be called *prevarication*.

Lastly, the prosecutor pleads, that it is unreasonable that he who does not deny the fact should escape by a cavil about a word. But the defendant insists upon his explication as agreeable to the law; and says, the fact is misrepresented and blackened, by affixing to it a wrong name.

3. The third state is that of *quality*, in which the dispute turns upon the justice of an action. And here the defendant does not deny he did the thing he is charged with; but asserts it to be right and equitable, from the circumstances of the case, and the motives which induced him to it.

And, first, he sometimes alleges, the reason of doing it was in order to prevent some other thing of worse consequence, which would otherwise have happened. We have an instance of this in the life of Epaminondas, who, with two other generals joined in the command with him, marched the Theban army into Peloponnesus against the Lacedemonians; but by the influence of a contrary faction at home, their commissions were superseded, and other generals sent to command the army. But Epaminondas, being sensible that, if he obeyed this order at that time, it would be attended with the loss of the whole army, and consequently the ruin of the state, refused to do it; and having persuaded the other generals to do the like, they happily finished the war in which they were engaged; and upon their return home, Epaminondas taking the whole matter upon himself, on his trial was acquitted. The arguments proper in this case are taken from the justice, usefulness, or necessity, of

the action. The accuser therefore will plead, that the fact was not just, profitable, nor necessary, considered either in itself or comparatively with that for the sake of which it is said to have been done: and he will endeavour to show, that what the defendant assigns for the reason of what he did might not have happened as he pretends. Besides, he will represent of what ill consequence it must be, if such crimes go unpunished. The defendant, on the other hand, will argue from the same heads, and endeavour to prove the fact was just, useful, or necessary. And he will further urge, that no just estimate can be made of any action, but from the circumstances which attend it; as the design, occasion, and motives for doing it; which he will represent in the most favourable light to his own cause, and endeavour to set them in such a view, as to induce others to think they could not but have done the same in the like circumstances.

Again, the cause of an action is sometimes charged by the defendant upon the party who received the damage, or some other person, who either made it necessary, or enjoined him to do it. The first of these was Milo's plea for killing Clodius, because he assaulted him with a design to take away his life. Here the fact is not denied, as in the case of Roscius above-mentioned, under the *conjectural* state; but justified from the reason of doing it. For that an assassin might be justly killed, Cicero shows both from law and reason. The accuser, therefore, in such a case, will, if there be room for it, deny the truth of this allegation. So the friends of Clodius affirmed that Milo was the aggressor, and not Clodius; which Cicero, in his defence of Milo, principally labours to refute. In the second case, the prosecutor will say, No one ought to offend because another has offended first; which defeats the course of public justice, renders the laws useless, and destroys the authority of the magistrate. The defendant, on the other hand, will endeavour to represent the danger and necessity of the case, which required an immediate remedy, and in that manner; and urges, that it was vain and impracticable to wait for redress in the ordinary way, and therefore no ill consequence can arise to the public. Thus Cicero, in defending Sextius, who was prosecuted for a riot in bringing armed men into the forum, shows that his design was only to repel force with force; which was then necessary, there being no other means left for the people to assemble, who were excluded by a mob of the contrary party. Of the third case we have also an example in Cicero, who tells us, that, "in making a league between the Romans and Samnites, a certain young nobleman was ordered by the Roman general to hold the swine (designed for a sacrifice); but the senate afterwards disapproving the terms, and delivering up their general to the Samnites, it was moved, Whether this young man ought not likewise to be given up." Those who were for it might say, that, to allege the command of another, is not a sufficient plea for doing an ill action; and this is what the Roman law now expressly declares. But in answer to that, it might be replied, that it was his duty to obey the command of his general, who was answerable for his own orders, and not those who were obliged to execute them; and therefore, to

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give up this young nobleman would be to punish one person for the fault of another.

Lastly, a fact is sometimes rather excused than defended, by pleading that it was not done designedly, or with any ill intent. This is called *concession*; and consists of two parts, *apology* and *intreaty*. The former represents the matter as the effect of inadvertency, chance, or necessity. Aristotle gives us an example of inadvertency or imprudence in a woman at Athens, who gave a young man a love-potion, which killed him; for which she was tried, but acquitted: though afterwards this was made criminal by the Roman law. The case of Adrastus, as related by Herodotus, is an instance of chance; who being intrusted by Cræsus with the care of his son, as they were hunting, killed him accidentally with a javelin which he threw at a boar. It is necessity, when a person excuses his making a default, from stress of weather, sickness, or the like. Thus Cicero pleaded his illness, contracted by the fatigue of a long journey, as an excuse for not appearing in the senate upon the summons of Mark Antony, who threatened to oblige him to it by pulling his house down. But what the defendant here attributes to inadvertency, chance, or necessity, the opposite party will attribute to design, negligence, or some other culpable reason; and represent it as a matter injurious to the public to introduce such precedents; and also produce instances, if that can be done, where the like excuses have not been admitted. On the other hand, the defendant will insist on his innocence, and show the hardship and severity of judging mens actions rather by the event, than from the intention: that such a procedure makes no difference between the innocent and the guilty; but must necessarily involve many honest men in ruin and destruction, discourage all virtuous and generous designs, and turn greatly to the prejudice of human society. He will also consider the instances alleged by the accuser, and show the difference between them and his own case. And, lastly, he will have recourse to intreaty, or a submissive address to the equity and clemency of the court, or party offended, for pardon; as Cicero has done in his oration to Cæsar, in favour of Ligarius.

CHAP. V. Of the Character and Address of an Orator.

¹²
Propriety
of manners
necessary in
an orator,
both with
respect to
character
and address.

HAVING considered and explained the first part of invention, which furnishes the orator with such arguments as are necessary for the proof of his subject, we are next to show what are the proper means to conciliate the minds of his hearers; to gain their affection; and to recommend both himself, and what he says, to their good opinion and esteem. For the parts of invention are commonly thus distinguished; that the first respects the *subject* of the discourse, the second the *speaker*, and the third the *hearers*. Now the second of these, what we have at present to explain, is by Quintilian called a *propriety of manners*. And in order to express this, it is necessary, as he tells us, "that every thing appear easy and natural, and the disposition of the speaker be discovered by his words." We may form an easy conception of this from the conduct of such persons as are most nearly concerned in each

others welfare. As when relations or friends converse together upon any affairs of importance, the temper and disposition of the speaker plainly shows itself by his words and manner of address. And what nature here directs to without colouring or disguise, the orator is to endeavour to perform by his art. Though indeed, if what a person says be inconsistent with his usual conduct and behaviour at other times, he cannot expect it should gain much credit, or make any deep impression upon his hearers: which may be one reason why the ancient rhetoricians make it so necessary a qualification in an orator, that he be a good man; since he should always be consistent with himself, and, as we say, talk in character. And therefore it is highly requisite, that he should not only gain the skill of assuming those qualities which the nature and circumstances of his discourse require him to express; but likewise, that he should use his utmost endeavours to get the real habits implanted in his mind. For as by this means they will be always expressed with greater ease and facility; so, by appearing constantly in the course of his life, they will have more weight and influence upon particular occasions.

Now there are four qualities, more especially suited to the character of an orator, which should always appear in his discourses, in order to render what he says acceptable to his hearers; and these are, *wisdom*, *integrity*, *benevolence*, and *modesty*.

1. *Wisdom* is necessary; because we easily give into those whom we esteem wiser and more knowing than ourselves. Knowledge is very agreeable and pleasant to all, but few make very great improvements in it; either by reason they are employed in other necessary affairs, and the mind of man cannot attend to many things at once; or because the way to knowledge at first is hard and difficult, so that persons either do not care to enter upon the pursuit of it, or, if they do, they are many times soon discouraged, and drop it, for want of sufficient resolution to surmount its difficulties. Such, therefore, as either cannot, or do not care to give themselves the trouble of examining into things themselves, must take up with the representation of others; and it is an ease to them to hear the opinion of persons whom they esteem wiser than themselves. No one loves to be deceived; and those who are fearful of being misled, are pleased to meet with a person, in whose wisdom, as they think, they can safely trust. The character of wisdom therefore is of great service to an orator, since the greater part of mankind are swayed by authority rather than arguments.

2. But this of itself is not sufficient, unless the opinion of *integrity* be joined with it. Nay, so far from it, that the greater knowledge and understanding a man is supposed to have, unless he likewise have the character of an honest man, he is often the more suspected. For knowledge without honesty, is generally thought to dispose a person, as well as qualify him, to deceive.

3. And to both these qualities the appearance of kindness and *benevolence* should likewise be added. For though a person have the reputation of wisdom and honesty, yet if we apprehend he is either not well affected to us, or at least regardless of our interest, we are in many cases apt to be jealous of him. Mankind are naturally swayed by their affections, and much influenced

Invention. influenced through love or friendship; and therefore nothing has a greater tendency to induce persons to credit what is said, than intimations of affection and kindness. The best orators have been always sensible what great influence the expressions of kindness and benevolence have upon the minds of others, to induce them to believe the truth of what they say; and therefore they frequently endeavour to impress them with the opinion of it. Thus Demosthenes begins his celebrated oration for Ctesiphon. "It is my hearty prayer (says he) to all the deities, that this my defence may be received by you with the same affection which I have always expressed for you and your city." And it is a very fine image of it which we have in Cicero, where, in order to influence the judges in favour of Milo, he introduces him speaking thus, as became a brave man, and a patriot, even upon the supposition he should be condemned by them: "I bid my fellow citizens adieu: may they continue flourishing and prosperous; may this famous city be preserved, my most dear country, however it has treated me; may my fellow citizens enjoy peace and tranquillity without me, since I am not to enjoy it with them, though I have procured it for them: I will withdraw, I will be gone."

4. *Modesty.* It is certain, that what is modestly spoken is generally better received than what carries in it an air of boldness and confidence. Most persons, though ignorant of a thing, do not care to be thought so; and would have some deference paid to their understanding. But he who delivers himself in an arrogant and assuming way seems to upbraid his hearers with ignorance, while he does not leave them to judge for themselves, but dictates to them, and as it were demands their assent to what he says; which is certainly a very improper method to win upon them. For not a few, when convinced of an error in such a way, will not own it; but will rather adhere to their former opinion, than seem forced to think right, when it gives another the opportunity of a triumph. A prudent orator therefore will behave himself with modesty, that he may not seem to insult his hearers; and will set things before them in such an engaging manner, as may remove all prejudice either from his person or what he asserts. This is particularly necessary in the exordium of a discourse. If the orator set out with an air of arrogance and ostentation, the self-love and pride of the hearers will be presently awakened, and will follow him with a very suspicious eye throughout all his progress. His modesty should discover itself not only in his expressions at the beginning, but in his whole manner; in his looks, in his gestures, in the tone of his voice. Every auditory take in good part those marks of respect and awe, which are paid to them by one who addresses them. Indeed the modesty of an introduction should never betray any thing mean or abject. It is always of great use to an orator, that together with modesty and deference to his hearers, he should show a certain sense of dignity, arising from a persuasion of the justice or importance of the subject on which he is to speak. For to speak timorously, and with hesitation, destroys the credit of what is offered; and so far as the speaker seems to distrust what he says himself, he often induces others to do the like.

Invention. But, as has been said already, great care is to be taken that these characters do not appear feigned and counterfeit. For what is fictitious can seldom be long concealed. And if this be once discovered, it makes all that is said suspected, how specious soever it may otherwise appear.

It is further necessary, that the orator should know the world, and be well acquainted with the different tempers and dispositions of mankind. Nor indeed can any one reasonably hope to succeed in this province, without well considering the circumstances of time and place, with the sentiments and dispositions of those to whom he speaks; which, according to Aristotle, may be distinguished four ways, as they discover themselves by the several *affections, habits, ages, and fortunes* of mankind. And each of these require a different conduct and manner of address.

The *affections* denote certain emotions of the mind, which, during their continuance, give a great turn to the disposition. For love prompts to one thing, and hatred to another. The like may be said of anger, lenity, and the rest of them.

Persons differ likewise according to the various *habits* of their mind. So a just man is inclined one way, and an unjust man another; a temperate man to this, and an intemperate man to the contrary.

And as to the several *ages* of men, Aristotle has described them very accurately; and how persons are differently affected in each of them. He divides the lives of men, considered as hearers, into three stages; youth, middle age, and old age.—Young men, he says, have generally strong passions, and are very eager to obtain what they desire; but are likewise very mutable, so that the same thing does not please them long. They are ambitious of praise, and quick in their resentments: lavish of their money, as not having experienced the want of it: frank and open, because they have not often been deceived; and credulous for the same reason. They readily hope the best, because they have not suffered much, and are therefore not so sensible of the uncertainty of human affairs; for which reason they are likewise more easily deceived. They are modest, from their little acquaintance with the world. They love company and cheerfulness, from the briskness of their spirits. In a word, they generally exceed in what they do; love violently, hate violently, and act in the same manner through the rest of their conduct.—The disposition of old men is generally contrary to the former. They are cautious, and enter upon nothing hastily; having in the course of many years been often imposed upon; having often erred, and experienced the prevailing corruption of human affairs; for which reason they are likewise suspicious, and moderate in their affections either of love or hatred. They pursue nothing great and noble, and regard only the necessities of life. They love money; having learnt by experience the difficulty of getting it, and how easily it is lost. They are fearful, which makes them provident. Commonly full of complaints, from bodily infirmities, and a deficiency of spirits. They please themselves rather with the memory of what is past, than with any future prospect; having so short a view of life before them, in comparison of what is already gone: for which reason also, they love to talk of things past; and prefer them

Invention. them to what is present, of which they have but little relish, and know they must shortly leave them. They are soon angry, but not to excess. Lastly, they are compassionate, from a sense of their own infirmities, which makes them think themselves of all persons most exposed.—Persons of a middle age, betwixt these two extremes, as they are freed from the rashness and temerity of youth, so they have not yet suffered the decays of old age. Hence in every thing they generally observe a better conduct. They are neither so hasty in their assent as the one, nor so minutely scrupulous as the other, but weigh the reasons of things. They regard a decency in their actions; are careful and industrious; and as they undertake what appears just and laudable upon better and more deliberate consideration than young persons, so they pursue them with more vigour and resolution than those who are older.

As to the different *fortunes* of mankind, they may be considered as noble, rich, or powerful; and the contrary to these.—Those of high birth, and noble extraction, are generally very tender of their honour, and ambitious to increase it; it being natural for all persons to desire an addition to those advantages of which they find themselves already possessed. And they are apt to consider all others as much their inferiors, and therefore expect great regard and deference should be shown them.—Riches, when accompanied with a generous temper, command respect from the opportunities they give of being useful to others; but they usually elate the mind, and occasion pride. For as money is commonly said to command all things, those who are possessed of a large share of it, expect others should be at their beck; since they enjoy that which all desire, and which most persons make the main pursuit of their lives to obtain.—But nothing is more apt to swell the mind than power. This is what all men naturally covet, even when perhaps they would not use it. But the views of such persons are generally more noble and generous than of those who only pursue riches and the heaping up of money. A state contrary to these gives a contrary turn of mind; and in lower life, persons dispositions usually differ according to their station and circumstances. A citizen and a courtier, a merchant and a soldier, a scholar and a peasant, as their pursuits are different, so is generally their turn and disposition of mind.

It is the orator's business, therefore, to consider these several characters and circumstances of life, with the different bias and way of thinking they give to the mind; that he may so conduct himself in his behaviour and manner of speaking, as will render him most acceptable, and gain him the good esteem of those whom he addresses.

CHAP. VI. *Of the Passions.*

²⁰
It is necessary, though difficult, to engage the interest of the passions.

As it is often highly necessary for the orator, so it requires his greatest skill, to engage the passions in his interest. Quintilian calls this *the soul and spirit of his art*. And, doubtless, nothing more discovers its empire over the minds of men, than this power to excite, appease, and sway their passions, agreeably to the design of the speaker. Hence we meet with the charac-

Invention. ters of *admirable, divine, and other splendid titles*, ascribed to eloquence by ancient writers. It has indeed been objected by some, that whatever high encomiums may be given of this art by the admirers of it, it is however disingenuous to deceive and impose upon mankind, as those seem to do, who, by engaging their passions, give a bias to their minds, and take them off from the consideration of the truth; whereas every thing should be judged of from the reasons brought to support it, by the evidence of which it ought to stand or fall. But in answer to this, it may be considered that all fallacy is not culpable. We often deceive children for their good; and physicians sometimes impose on their patients, to come at a cure. And why, therefore, when persons will not be prevailed with by reason and argument, may not an orator endeavour, by engaging their passions, to persuade them to that which is for their advantage? Besides, Quintilian makes it a necessary qualification of an orator, that he be an honest man, and one who will not abuse his art. But since those of a contrary character will leave no methods untried in order to carry their point, it is requisite for those who design well to be acquainted with all their arts, without which they will not be a match for them; as in military affairs it is highly advantageous for the general of an army to get himself informed of all the designs and stratagems of the enemy, in order to counteract them. Indeed this part of oratory is not necessary at all times, nor in all places. The better prepared persons are to consider truth, and act upon the evidence of it, the less occasion there appears for it. But the greater part of mankind, either do not duly weigh the force of arguments, or refuse to act agreeably to their evidence. And where this is the case, that persons will neither be convinced by reason, nor moved by the authority of the speaker, the only way left to put them upon action, is to engage their passions. For the passions are to the mind, what the wind is to a ship: they move, and carry it forward; and he who is without them, is in a manner without action, dull and lifeless. There is nothing great or noble to be performed in life, wherein the passions are not concerned. The Stoics, therefore, who were for eradicating the passions, both maintained a thing in itself impossible, and which, if it was possible, would be of the greatest prejudice to mankind. For while they appeared such zealous assertors of the government of reason, they scarce left it any thing to govern; for the authority of reason is principally exercised in ruling and moderating the passions, which, when kept in a due regulation, are the springs and motives to virtue. Thus hope produces patience, and fear industry; and the like might be shown of the rest. The passions therefore are not to be extirpated, as the Stoics asserted, but put under the direction and conduct of reason. Indeed where they are ungovernable, and resist the controul of reason, they are, as some have fitly called them, *diseases of the mind*; and frequently hurry men into vice, and the greatest misfortunes of life: just as the wind, when it blows moderately, carries on the ship; but if it be too boisterous and violent may overset her. The charge therefore brought against this art, for giving rules to influence the passions, appears groundless and unjust; since the proper use of the passions is, not to hinder the exercise

Invention. exercise of reason, but to engage men to act agreeably to reason. And if an ill use be sometimes made of this, it is not the fault of the art, but of the artist.

We shall here consider the passions, as they may be separately referred, either to *demonstrative*, *deliberative*, or *judicial* discourses; though they are not wholly confined to any of them.

²¹ Of the passions which may be referred to demonstrative discourses.

1. To the *demonstrative* kind, we may refer *joy* and *sorrow*, *love* and *hatred*, *emulation* and *contempt*.

Joy is an elation of the mind, arising from a sense of some present good. Such a reflection naturally creates a pleasant and agreeable sensation, which ends in a delightful calm and serenity. This is heightened by a description of former evils, and a comparison between them and the present felicity. Thus Cicero endeavours to excite in the minds of his fellow-citizens the highest sense of joy and delight at Catiline's departure from Rome, by representing to them the imminent danger which threatened both them and the city while he continued among them.

Sorrow, on the contrary, is an uneasiness of mind arising from a sense of some present evil. This passion has generally a place in funeral discourses. And it may be heightened, like the former, by comparison, when any past happiness is set in opposition to a present calamity. Hence Cicero aggravates the sorrow at Rome occasioned by the death of Metellus, from his character, and great services to the public, while living.

Love excites us to esteem any person for some excellency, and to do him all the good in our power. It is distinguished from *friendship*, which is mutual; and therefore love may continue where friendship is lost; that is, the affection may remain on one side. And when we assist a person from no other motive but to do him a kindness, Aristotle calls this *good-will*. Love takes its rise from a variety of causes. Generosity, benevolence, integrity, gratitude, courtesy, and other social virtues, are great incitements to love any one endued with such qualities. And persons generally love those who are of a like disposition with themselves and pursue the same views. It is therefore the chief art of a flatterer to suit himself in every thing to the inclination of the person whose good graces he courts. When the orator would excite this affection towards any person, it is proper to show, that he is possessed of at least some, if not all, of these agreeable qualities. When the conspirators with Catiline were to be brought to justice, Cicero was very sensible of the envy he should contract on that account, and how necessary it was for him to secure the love of the Roman senate for his support and protection in that critical juncture. And this he endeavours to do in his fourth oration against Catiline, by representing to them in the most pathetic manner, that all the labours he underwent, the difficulties he consisted with, and the dangers to which he was exposed on that account, were not for his own sake, but for their safety, quiet, and happiness.

Hatred is opposed to love, and produced by the contrary dispositions. And therefore persons hate those who never did them any injury, from the ill opinion they have of their base and vicious inclinations. So that the way to excite this passion is, by showing that any one has committed some heinous

fact with an ill intent. And the more nearly affected persons are by such actions, in what they account of the greatest concern, the higher in proportion their hatred rises. Since life therefore is esteemed the most valuable good, Cicero endeavours to render Mark Antony odious to the citizens of Rome, by describing his cruelty.

Emulation is a disquiet, occasioned by the felicity of another, not because he enjoys it, but because we desire the like for ourselves. So that this passion is in itself good and laudable, as it engages men to pursue those things which are so. For the proper objects of emulation are any advantages of mind, body, or fortune, acquired by study or labour.

Emulation therefore is excited by a lively representation of any desirable advantages which appear to be attainable, from the example of others who are or have been possessed of them. But where the felicity of another occasions an uneasiness, not from the want of it, but because he enjoys it, this passion is called *envy*, which the ancients describe as an hideous monster, feeding upon itself, and being its own tormentor. Aristotle justly observes, that it most usually affects such persons as were once upon a level with those they envy. For most men naturally think so well of themselves, that they are uneasy to see those who were formerly their equals advanced above them. But, as this is a base and vicious passion, the orator is not to be informed how to excite it, but how to lessen or remove it. And the method prescribed by Cicero for this purpose is, to show that the things which occasioned it have not happened to the envied person undeservedly, but are the just reward of his industry or virtue; that he does not so much convert them to his own profit or pleasure, as to the benefit of others; and that the same pains and difficulties are necessary to preserve them with which they were at first acquired.

Contempt is opposed to *emulation*, and arises from misconduct in things not of themselves vicious: As where a person either acts below his station and character, or affects to do that for which he is not qualified. Thus Cicero endeavours to expose Cæcilius, and bring him into contempt of the court, for pretending to rival him in the accusation of Verres, for which he was altogether unfit.

2. To *deliberative* discourses may be referred *fear*, *hope*, and *shame*.

Fear arises from the apprehension of some great and impending evil. For the greatest evils, while they appear at a distance, do not much affect us. Such persons occasion fear, who are possessed of power, especially if they have been injured, or apprehend so: likewise those who are addicted to do injuries, or who bear us an ill will. And the examples of others, who have suffered in a like case, or from the same persons, help to excite fear. From the circumstances therefore either of the thing or person, it will not be difficult for the orator to offer such arguments as may be proper to awaken this passion. So Demosthenes, when he would persuade the Athenians to put themselves in a condition of defence against King Philip, enumerates the several acts of hostility already committed by him against the neighbouring states. And because mens private concerns generally more affect them than what relates to the public, it is proper sometimes

²² Of the passions which may be referred to deliberative discourses.

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to show the necessary connection these have with each other, and how the ruin of one draws the other after it.

The contrary passion to *fear* is *hope*; which arises either from a prospect of some future good, or the apprehension of safety from those things which occasion our fear. Young persons are easily induced to hope the best, from the vigour of their spirits. And those who have escaped former dangers are encouraged to hope for the like success for the future. The examples of others also, especially of wise and considerate men, have often the same good effect. To find them calm and sedate when exposed to the like dangers, naturally creates confidence and the hopes of safety. But nothing gives persons such firmness and steadiness of mind, under the apprehension of any difficulties, as a consciousness of their own integrity and innocence. Let dangers come from what quarter they will, they are best prepared to receive them. They can calmly view an impending tempest, observe the way of its approach, and prepare themselves in the best manner to avoid it. In Cicero's oration for the Manilian law, he encourages the Roman citizens to hope for success against Mithridates, if they chose Pompey for their general, from the many instances of his former successes, which he there enumerates.

Shame arises from the apprehension of those things that hurt a person's character. *Modesty* has been wisely implanted in mankind by the great Author of nature, as a guardian of virtue, which ought for this reason to be cherished with the greatest care; because, as Seneca has well observed, "if it be once lost, it is scarce ever to be recovered." Therefore the true cause or foundation of shame is any thing base or vicious; for this wounds the character, and will not bear reflection. And he must arrive at no small degree of insensibility, who can stand against such a charge, if he be conscious to himself that it is just. Therefore, to deter persons from vicious actions, or to expose them for the commission of them, the orator endeavours to set them in such a light as may most awaken this passion, and give them the greatest uneasiness by the reflection. And because the bare representation of the thing itself is not always sufficient for this purpose, he sometimes enforces it by enlarging the view, and introducing those persons as witnesses of the fact for whom they are supposed to have the greatest regard. Thus, when some of the Athenians, in an arbitration about certain lands which had been referred to them by the contending parties, proposed it as the shortest way of deciding the controversy, to take the possession of them into their own hands; Cydias, a member of the assembly, to dissuade them from such an unjust action, desired them to imagine themselves at that time in the general assembly of the states of Greece (who would all hear of it shortly), and then consider how it was proper to act. But where persons labour under an excess of modesty, which prevents them from exerting themselves in things fit and laudable, it may sometimes be necessary to show that it is faulty and ill grounded. On the other hand, *immodesty*, or impudence, which consists in a contempt of such things as affect the reputation, can never be too much discouraged and exposed. And the way of doing this is to make use of such arguments as are most proper to

N^o 250.

excite shame. We have a very remarkable instance of it in Cicero's second Philippic, wherein he affixes this character upon Mark Antony through every scene of his life.

3. To *judicial* discourses, may be referred *anger* and *lenity*, *pity*, and *indignation*.

Anger is a resentment, occasioned by some affront, or injury, done without any just reason. Now men are more inclined to resent such a conduct, as they think they less deserve it. Therefore persons of distinction and figure, who expect a regard should be paid to their character, can the less bear any indications of contempt. And those who are eminent in any profession or faculty, are apt to be offended if reflections are cast either upon their reputation or art. Magistrates also, and persons in public stations, sometimes think it incumbent on them to resent indignities, for the support of their office. But nothing sooner inflames this passion, than if good services are rewarded with slights and neglect. The instance of Narses, the Roman general, is remarkable in this kind; who, after he had been successful in his wars with the Goths, falling under the displeasure of the emperor Justin, was removed from the government of Italy, and received by the empress with this taunt, *That he must be sent to weave among the girls*; which so provoked him, that he said he would weave such a web as they should never be able to unravel. And accordingly, he soon after brought down the Longobards, a people of Germany, into Italy; where they settled themselves in that part of the country, which from them is now called *Lombardy*. (See NARSES). The time and place in which an injury was done, and other circumstances that attended it, may likewise contribute very much to heighten the fact. Hence Demosthenes, in his oration against Midias, endeavours to aggravate the injury of being struck by him, both as he was then a magistrate, and because it was done at a public festival. From hence it appears, that the persons who most usually occasion this passion are such as neglect the rules of decency, condemn and insult others, or oppose their inclinations; as likewise the ungrateful, and those who violate the ties of friendship, or requite favours with injuries. But when the orator endeavours to excite anger, he should be careful not to exceed due bounds in aggravating the charge, lest what he says appear rather to proceed from prejudice, than a strict regard to the demerit of the action.

Lenity is the remission of anger. The designs of mens actions are principally to be regarded; and therefore what is done ignorantly, or through inadvertency, is sooner forgiven. Also to acknowledge a fault, submit, and ask pardon, are the ready means to take off resentment. For a generous mind is soon cooled by submission. Besides, he who repents of his fault, does really give the injured party some satisfaction, by punishing himself; as all repentance is attended with grief and uneasiness of mind, and this is apt very much to abate the desire of revenge. As, on the contrary, nothing is more provoking, than when the offender either audaciously justifies the fact, or confidently denies it. Men are likewise wont to lay aside their resentment, when their adversaries happen by some other means to suffer what they think a sufficient satisfaction. Lastly, easy circumstances, a lucky inci-

dent,

Invention.

²³ Of the passions which may be referred to judicial discourses.

Invention. dent, or any thing which gives the mind a turn to mirth and pleasure, has a natural tendency to remove anger. For anger is accompanied with pain and uneasiness, which very ill suit joy and cheerfulness. The orator, therefore, in order to assuage and pacify the minds of his auditors, will endeavour to lessen their opinion of the fault, and by that means to take off the edge of their resentment. And to this purpose, it will be proper either to represent that the thing was not designed, or that the party is sorry for it; or to mention his former services; as also to show the credit and reputation which will be gained by a generous forgiveness. And this last topic is very artfully wrought up by Cicero, in his address to Cæsar, in favour of Ligarius.

Pity arises from the calamities of others, by reflecting, that we ourselves are liable to the like misfortunes. So that evils, considered as the common lot of human nature, are principally the cause of pity. And this makes the difference between *pity* and *good-will*, which arises merely from a regard to the circumstances of those who want our assistance. But considering the uncertainty of every thing about us, he must seem in a manner divested of humanity, who has no compassion for the calamities of others; since there is no affliction which happens to any man, but either that, or some other as great, may fall upon himself. But those persons are generally soonest touched with this passion, who have met with misfortunes themselves. And by how much greater the distress is, or by how much the person appears less deserving it, the higher pity does it excite: for which reason, persons are generally most moved at the misfortunes of their relations and friends, or those of the best figure and character. The orator, therefore, in order to excite the greater pity, will endeavour to heighten the idea of the calamity, from the several circumstances both of the thing itself and the person who labours under it. A fine example of this may be seen in Cicero's defence of Muræna, *cap. 40. &c.*

Indignation, as opposed to *pity*, is an uneasiness at the felicity of another who does not seem to deserve it. But this respects only external advantages, such as riches, honours, and the like; for virtues cannot be the object of this passion. Aristotle therefore says, "that pity and indignation are generally to be found in the same persons, and are both evidences of a good disposition." Now the orator excites this passion, by

showing the person to be unworthy of that felicity which he enjoys. And as, in order to move compassion, it is sometimes of use to compare the former happy state of the person with his present calamity; so here, the greater indignation is raised, by comparing his former mean circumstances with his present advancement: as Cicero does in the case of Vatinius.

These are the passions with which an orator is principally concerned. In addressing to which, not only the greatest warmth and force of expression is often necessary; but he must likewise first endeavour to impress his own mind with the same passion he would excite in others.

A man may convince, and even persuade others to act, by mere reason and argument. But that degree of eloquence which gains the admiration of mankind, and properly denominates one an orator, is never found without warmth or passion. Passion, when in such a degree as to rouse and kindle the mind, without throwing it out of the possession of itself, is universally found to exalt all the human powers. It renders the mind infinitely more enlightened, more penetrating, more vigorous and masterly, than it is in its calm moments. A man, actuated by a strong passion, becomes much greater than he is at other times. He is conscious of more strength and force; he utters greater sentiments, conceives higher designs, and executes them with a boldness and a felicity of which on other occasions he could not think himself capable. But chiefly, with respect to persuasion, is the power of passion felt. Almost every man in passion is eloquent. Then he is at no loss for words and arguments. He transmits to others, by a sort of contagious sympathy, the warm sentiments which he feels; his looks and gestures are all persuasive; and nature here shows herself infinitely more powerful than art. This is the foundation of that just and noted rule, *Si vis me flere, dolendum est primum ipsi tibi.*

The warmth, however, which we express, must be suited to the occasion and the subject; for nothing can be more preposterous than an attempt to introduce great vehemence into a subject, which is either of slight importance, or which, by its nature, requires to be treated of calmly. A temperate tone of speech is that for which there is most frequent occasion; and he who is on every subject passionate and vehement, will be considered as a blusterer, and meet with little regard.

PART II. OF DISPOSITION.

AS *Invention* supplies the orator with necessary materials, so *Disposition* directs him how to place them in the most proper and suitable order. Disposition therefore, considered as a part of oratory, naturally follows invention. And what is here chiefly intended by it is, the placing the several parts of a discourse in a just method and dependence upon one another.

Writers are not all agreed in determining the parts of an oration; though the difference is rather in the manner of considering them, than in the things themselves. But Cicero, whom we shall here follow, mentions

six, namely, *Introduction, Narration, Proposition, Confirmation, Confutation, and Conclusion.*

CHAP. I. Of the Introduction.

THE design of this is to prepare the minds of the hearers for a suitable reception of the remaining parts that are to follow. And for this end, three things are requisite; that the orator gain the good opinion of his hearers, that he secure their attention, and give them some general notion of his subject.

1. *Good opinion.* When the orator introduces his discourse

3 D

discourse

²⁴ Introduction gains the hearts and attention of the audience, and gives a general notion of the subject.

Disposition. discourse with his own person, he will be careful to do it with modesty, and seem rather to extenuate his virtues and abilities, than to magnify them. And where the nature of the subject may seem to require it, he will endeavour to show, that some just and good reason induced him to engage in it. We have a very fine example of this in Cicero's oration for the poet Aulus Licinius Archias, which begins thus: "If I have any natural genius, which I am sensible is very small, or any ability in speaking, wherein I own I have been very conversant; or any skill acquired from the study and precepts of the best arts, to which my whole life has been devoted; this Aulus Licinius has, in a particular manner, a right to demand of me the fruit of all these things. For as far back as I can remember, and call to mind what passed in my youth to the present time, he has been my chief adviser and encourager both to undertake and pursue this course of studies." When the orator sets out with the persons of those to whom the discourse is made, it is not unusual to commend them for their virtues, and those especially which have a more immediate relation to the present subject. Thus Cicero begins his oration of thanks for the pardon of Marcellus, with an encomium upon the mildness, clemency, and wisdom of Cæsar, to whom it was addressed. But sometimes the orator expresses his gratitude for past favours; as Cicero has done in his orations, both to the people and senate of Rome, after his return from banishment.— And at other times he declares his concern for them and their interest; in which manner Cicero begins his fourth oration against Catiline, which was made in the senate. "I perceive (says he) that all your countenances and eyes are turned on me; I perceive that you are solicitous, not only for your own danger, and that of the state, but for mine likewise, if that should be removed. Your affection for me is pleasant in misfortunes, and grateful in sorrow; but I adjure you to lay it aside, and, forgetting my safety, consider yourselves and your children." But in judicial cases, both the character of the person whose cause he espouses, and that of the adverse party likewise, furnish the orator with arguments for exciting the good-will of his hearers: The former, by commemorating his virtues, dignity, or merits, and sometimes his misfortunes and calamities. So Cicero, in his defence of Flaccus, begins his oration in commending him on the account of his services done to the public, the dignity of his family, and his love to his country. And Demosthenes, in his oration against Midias, sets out with a recital of his vices, in order to recommend his own cause to the favourable opinion of the court.

2. *Attention.* On this head, Cicero says, "We shall be heard attentively on one of these three things; if we propose what is great, necessary, or for the interest of those to whom the discourse is addressed." So that, according to him, the topics of attention are much the same with those of good opinion, when taken from the subject. And indeed, people are naturally led to attend either to those things or persons of which they have entertained a favourable opinion. But in order to gain this point, the orator sometimes thinks it proper to request the attention of his audience. Thus Cicero, in his defence of Cluentius, after having shown the heinousness of the charge against

him, concludes his introduction in the following manner, speaking to the judges: "Wherefore I intreat, that while I briefly and clearly reply to a charge of many years standing, you will, according to your usual custom, give me a kind and attentive hearing." And again, in his second Philippic, addressing himself to the senate: "But as I must say something for myself, and many things against Mark Antony; one of these I beg of you, that you will hear me kindly, while I speak for myself; and the other I will undertake for, that when I speak against him, you shall hear me with attention." But though the introduction be the most usual and proper place for gaining attention, yet the orator finds it convenient sometimes to quicken and excite his hearers in other parts of his discourse, when he observes they flag, or has something of moment to offer.

3. Some *general account* of the subject of the discourse. This is always necessary, which the two others are not. And therefore it must be left to the prudence of the orator when to use or omit them as he shall judge proper, from the nature of his discourse, the circumstance of his hearers, and how he stands with them. But some account of the subject is what cannot be neglected. For every one expects to be soon informed of the design of the speaker, and what he proposes to treat of. Nor when they are all made use of, is it necessary they should always stand in the order we have here placed them. Cicero sometimes enters immediately upon his subject, and introduces the other heads afterwards. As in his third oration against Catiline, made to the body of the Roman people, which begins thus: "You see that the state, all your lives, estates, fortunes, wives and children, and this seat of the greatest empire, the most flourishing and beautiful city, having by the favour of heaven towards you, and my labours, counsels, and dangers, been this day rescued from fire and sword and the very jaws of destruction, are preserved and restored to you." And then he proceeds to recommend himself to their esteem and benevolence, from the consideration of these benefits.

These are the heads which commonly furnish matter for this part of a discourse. But orators often take occasion from the time, place, largeness of the assembly, or some other proper circumstance, to compliment their hearers, recommend themselves, or introduce the subject upon which they are about to treat. Instances of each of these may be met with in several of Cicero's orations. And sometimes they set out with some comparison, similitude, or other ornament, which they accommodate to the occasion of their discourse. Thus Isocrates enters upon his celebrated panegyric in praise of his countrymen the Athenians with the following comparison: "I have often wondered what could be their design who brought together these assemblies, and instituted the gymnastic sports, to propose so great rewards for bodily strength; and to vouchsafe no honour to those who applied their private labours to serve the public, and so cultivated their minds as to be serviceable to others, to whom they ought to have shown greater regard. For although the strength of a champion was doubled, no benefit would from thence accrue to others; but all enjoy the prudence of one man, who will hearken to his advice." In some cases, orators

²⁵ Introduction is not confined to these heads, but can admit of other matter, if by the circumstances of the case.

Disposition. orators have recourse to a more covert and artful way of opening their subject, endeavour to remove jealousies, apologize for what they are about to say, and seem to refer it to the candour of the hearers to judge of it as they please. Cicero appears to have been a perfect master of this art, and used it with great success. Thus in his seventh Philippic, where he seems to express the greatest concern, lest what he was about to say should give any offence to the senate to whom he was speaking: "I (says he) who always declared for peace, and to whom peace among ourselves, as it is wished for by all good men, was in a particular manner desirable; who have employed all my industry in the forum, in the senate, and in the defence of my friends, whence I have arrived to the highest honours, a moderate fortune, and what reputation I enjoy; I therefore, who owe what I am to peace, and without it could not have been the person I am, be that what it will, for I would arrogate nothing to myself; I speak with concern and fear, how you will receive what I am going to say; but I beg and intreat you, from the great regard I have always expressed for the support and advancement of your honour, that if any thing said by me should at first appear harsh or unfit to be received, you will notwithstanding please to hear it without offence, and not reject it till I have explained myself: I then, for I must repeat it again, who have always approved of peace, and promoted it, am against a peace with Mark Antony." This is called *insinuation*; and may be necessary, where a cause is in itself doubtful, or may be thought so from the received notions of the hearers, or the impressions already made upon them by the contrary side. An honest man would not knowingly engage in a bad cause; and yet, through prevailing prejudice, that may be so esteemed which is not so in itself. In these cases, therefore, great caution and prudence are necessary to give such a turn to things, and place them in that view as may be least liable to offence. And because it sometimes happens that the hearers are not so much displeased at the subject as the person, Quintilian's rule seems very proper, when he says, "if the subject displeases, the character of the person should support it; and when the person gives offence, he should be helped by the cause."

CHAP. II. Of Narration.

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Narration
brings forward all those circumstances of a case, &c. in their proper and natural order, which are calculated to set it in a just or a strong light.

THE orator having prepared his hearers to receive his discourses with candour and attention, and acquainted them with his general design in the introduction, before he proceeds directly to his subject, often finds it necessary to give some account of what preceded, accompanied, or followed upon it. And this he does in order to enlarge the view of the particular point in dispute, and place it in a clearer light. This is called *narration*; which is a recital of something done, in the order and manner in which it was done. Hence it is easy to perceive what those things are which properly enter into a narration. And such are the cause, manner, time, place, and consequences of an action; with the temper, fortune, views, ability, associates, and other circumstances of those concerned in it. Not that each of these particulars is necessary in every narration; but so many of them at least as are requisite to set the matter in a just light,

and make it appear credible. Besides, in relating a fact, the orator does not content himself with such an account of it as is barely sufficient to render what he says intelligible to his hearers; but describes it in so strong and lively a manner, as may give the greatest evidence to his relation, and make the deepest impression upon their minds. And if any part of it appears at present less probable, he promises to clear up and remove any remaining doubts in the progress of his discourse. For the foundation of his reasoning afterwards is laid in the narration, from whence he takes his arguments for the confirmation. And therefore it is a matter of no small importance that this part be well managed, since the success of the whole discourse so much depends upon it. See NARRATION.

There are four properties required in a good narration; that it be short, clear, probable, and pleasant.

1. The *brevity* of a narration is not to be judged of barely from its length: for that may be too long, which contains but a little; and that too short, which comprehends a great deal. Wherefore this depends upon the nature of the subject, since some things require more words to give a just representation of them, and others fewer. That may properly therefore be called a *short narration*, which contains nothing that could well have been omitted, nor omits any thing which was necessary to be said. Now, in order to avoid both these extremes, care should be taken not to go farther back in the account of things, nor to trace them down lower, than the subject requires; to say that only in the general, which does not need a more particular explication; not to assign the causes of things, when it is enough to show they were done; and to omit such things as are sufficiently understood, from what either preceded, or was consequent upon them. But the orator should be careful, lest, while he endeavours to avoid prolixity, he run into obscurity. Horace was very sensible of this danger, when he said:

By striving to be short, I grow obscure.

2. *Perspicuity*. This may justly be esteemed the chief excellency of language. For as the design of speech is to communicate our thoughts to others, that must be its greatest excellence which contributes most to this end; and that, doubtless, is perspicuity. As perspicuity therefore is requisite in all discourse, so it is particularly serviceable in a narration, which contains the substance of all that is to be said afterwards. Wherefore, if this be not sufficiently understood, much less can those things which receive their light from it. Now the following things render a narration clear and plain: Proper and significant words, whose meaning is well known and determined; short sentences, though full and explicit, whose parts are not perplexed, but placed in their just order; proper particles to join the sentences, and show their connection and dependence on each other; a due regard to the order of time, and other circumstances necessary to be expressed; and, lastly, suitable transitions.

3. *Probability*. Things appear probable when the causes assigned for them appear natural; the manner in which they are described is easy to be conceived; the consequences are such as might be expected; the characters of the persons are justly represented;

Disposition. and the whole account is well attested, consistent with itself, and agreeable to the general opinion. Simplicity likewise in the manner of relating a fact, as well as in the style, without any reserve or appearance of art, contributes very much to its credibility. For truth loves to appear naked and open, stripped of all colouring or disguise. The conspiracy of Catiline was so daring and extravagant, that no one but such a desperado could ever have undertaken it with any hopes of success. However, Cicero's account of it to the senate was so full and exact, and so well suited to the character of the person, that it presently gained credit. And therefore, when, upon the conclusion of Cicero's speech, Catiline, who was present, immediately stood up, and desired they would not entertain such hard thoughts of him, but consider how much his family had always been attached to the public interest, and the great services they had done the state; their resentments rose so high, that he could not be heard: upon which he immediately left the city, and went to his associates.

4. The last thing required in a narration is, that it be *pleasant* and *entertaining*. And this is more difficult, because it does not admit of that accurate composition and pompous dress which delight the ear, and recommend some other parts of a discourse. For it certainly requires no small skill in the speaker, while he endeavours to express every thing in the most natural, plain, and easy manner, not to grow flat and tiresome. For Quintilian's remark is very just, that "the most experienced orators find nothing in eloquence more difficult, than what all who hear it fancy they could have said themselves." And the reason of this seems very obvious. For as all art is an imitation of nature, the nearer it resembles that, the more perfect it is in its kind. Hence unexperienced persons often imagine that to be easiest which suits best with those natural ideas to which they have been accustomed; till, upon trial, they are convinced of their mistake. Wherefore, to render this part of a discourse pleasant and agreeable, recourse must be had to variety both in the choice of words and turns of the expression. And therefore questions, admirations, interlocutions, imagery, and other familiar figures, help very much to diversify and enliven a narration, and prevent it from becoming dull and tedious, especially when it is carried on to any considerable length.

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The uses of Having given a brief account of the nature and properties of a narration, we shall now proceed to consider the uses of it.

Laudatory orations are usually as it were a sort of continued narration, set off and adorned with florid language and fine images proper to grace the subject, which is naturally so well fitted to afford pleasure and entertainment. Wherefore a separate narration is more suited to *deliberative* and *judicial* discourses. In Cicero's oration for the Manilian law (which is of the former kind), the design of the narration is to show the Roman people the necessity of giving Pompey the command of the army against king Mithridates, by representing the nature of that war, which is done in the following manner: "A great and dangerous war (says he) threatens your revenues and allies from two very powerful kings, Mithridates and Tigranes; one of whom not being pursued after his defeat, and the

Disposition. other provoked, they think they have an opportunity to seize Asia. Letters are daily brought from those parts to worthy gentlemen of the equestrian order, who have large concerns there in farming your revenues: they acquaint me, as friends, with the state of the public affairs, and danger of their own; that many villages in Bithynia, which is now your province, are burnt down; that the kingdom of Ariobarzanes, which borders upon your revenues, is entirely in the enemy's power; that Lucullus, after several great victories, is withdrawn from the war; that he who succeeds him is not able to manage it; that all the allies and Roman citizens wish and desire the command of that war may be given to one particular person; and that he alone, and no other, is dreaded by the enemies. You see the state of the case; now consider what ought to be done." Here is an unhappy scene of affairs, which seemed to call for immediate redress. The causes and reasons of it are assigned in a very probable manner, and the account well attested by persons of character and figure. And what the consequences would be, if not timely prevented, no one could well be ignorant. The only probable remedy suggested in general is, the committing that affair to one certain person, which he afterwards shows at large could be no other than Pompey. But in Cicero's defence of Milo (which is of the *judicial* kind), the design of the narration, which is greatly commended by Quintilian, is to prove that, in the combat between Clodius and Milo, the former was the aggressor. And in order to make this appear, he gives a summary account of the conduct of Clodius the preceding year; and from the course of his actions and behaviour, shows the inveterate hatred he bore to Milo, who obstructed him in his wicked designs. For which cause he had often threatened to kill him, and given out that he should not live beyond such a time: and accordingly he went from Rome without any other apparent reason, but that he might have an opportunity to attack him in a convenient place near his own house, by which he knew Milo was then obliged to pass. Milo was in the senate that day, where he staid till they broke up, then went home, and afterwards set forward on his journey. When he came to the place in which he was to be assaulted, Clodius appeared every way prepared for such a design, being on horseback, and attended with a company of desperate ruffians ready to execute his commands; whereas Milo was with his wife in a chariot, wrapped up in his cloak, and attended with servants of both sexes. These were all circumstances which preceded the fact. And as to the action itself, with the event of it, the attack, as Cicero says, was begun by the attendants of Clodius from an higher ground, who killed Milo's coachman: upon which Milo, throwing off his cloak, leaped out, and made a brave defence against Clodius's men, who were got about the chariot. But Clodius, in the heat of the skirmish, giving out that Milo was killed, was himself slain by the servants of Milo, to avenge, as they thought, the death of their master. Here seems to be all the requisites proper to make this account credible. Clodius's open and avowed hatred of Milo, which proceeded so far as to threaten his life; the time of his leaving Rome; the convenience of the place; his habit and company so different from those

of

Disposition of Milo; joined with his known character of a most profligate and audacious wretch, could not but render it very probable that he had formed that design to kill Milo. And which of them began the attack might very reasonably be credited from the advanced ground on which Clodius and his men were placed; the death of Milo's coachman at the beginning of the combat; the skirmish afterwards at the chariot; and the reason of Clodius's own death at last, which does not appear to have been intended, till he had given out that Milo was killed.

But a distinct and separate narration is not always necessary in any kind of discourse. For if the matter be well known before, a set and formal narrative will be tedious to the hearers. Or if one party has done it already, it is needless for the other to repeat it. But there are three occasions especially, in which it may seem very requisite: when it will bring light to the subject; when different accounts have already been given out concerning it; or when it has been misrepresented by the adverse party. If the point in controversy be of a dubious nature, or not sufficiently known to the hearers, a distinct account of the matter, with the particular circumstances attending it, must be very serviceable, in order to let them into a true state of the case, and enable them to judge of it with greater certainty.

Moreover, where the opposite party has set the matter in a false light by some artful and invidious turn, or loaded it with any odious circumstances, it seems no less necessary that endeavours should be used to remove any ill impressions, which otherwise might remain upon the minds of the hearers, by a different and more favourable representation. And if any thing can be fixed upon to make the contrary account appear absurd or incredible, it ought particularly to be remarked. Thus Cicero, in his defence of Sextus Roscius, shows that he was many miles distant from Rome at the time he was charged with having killed his father there. "Now (says he), while Sextus Roscius was at Ameria, and this Titus Roscius [*his accuser*] at Rome, Sextus Roscius [*the father*] was killed at the baths on Mount Palatine, returning from supper. From whence I hope there can be no doubt who ought to be suspected of the murder. And, were not the thing plain of itself, there is this farther suspicion to fix it upon the prosecutor; that, after the fact was committed, one Manlius Glaucia, an obscure fellow, the freedman, client, and familiar, of this Titus Roscius, first carried the account of it to Ameria, not to the son of the deceased, but to the house of Titus Capito his enemy;" with more to the same purpose. But what we bring it for is, to show the use which Cicero makes of this narration for retorting the crime upon the prosecutors.

But the orator should be very careful, in conducting this part, to avoid every thing which may prejudice the cause he espouses. Falshood, and a misrepresentation of facts, are not to be justified; but no one is obliged to say those things which may hurt himself. We shall just mention one instance of this from Cicero, where he has shown great skill in this respect, in pleading before Cæsar for the pardon of Ligarius, who had joined with Pompey in the civil war. For Ligarius,

enemy to Cæsar, and so esteemed by Cæsar himself; Cicero very artfully endeavours in his narration to take off the force of this charge, by showing, that, when the war first broke out, he refused to engage in it; which he would not have done, had he borne any personal hatred to Cæsar. "Quintus Ligarius (says he), before there was any suspicion of a war, went into Africa as a legate to the proconsul Caius Confidius; in which he so approved himself, both to the Roman citizens and allies, that, when Confidius left the province, the inhabitants would not be satisfied he should leave the government in the hands of any other person. Therefore Quintus Ligarius having excused himself in vain for some time, accepted of the government against his will; which he so managed during the peace, that both the citizens and allies were greatly pleased with his integrity and justice. The war broke out on a sudden, which those in Africa did not hear of till it was begun: but upon the news of it, partly through inconsiderate haste, and partly from blind fear, they looked out for a leader, first for their own safety, and then as they were affected; when Ligarius, thinking of home, and desirous to return to his friends, would not be prevailed on to engage in any affairs. In the mean time, Publius Accius Varus, the prætor, who was formerly governor of Africa, coming to Utica, recourse was immediately had to him, who very eagerly took upon himself the government; if that can be called a *government*, which was conferred on a private man by the clamour of the ignorant multitude, without any public authority. Ligarius, therefore, who endeavoured to avoid every thing of that kind, ceased to act soon after the arrival of Varus." Here Cicero ends his narrative. For though Ligarius afterwards joined with Pompey's party, yet to have mentioned that, which was nothing more than what many others had done, whom Cæsar had already pardoned, could have served only to increase his displeasure against him. And therefore he doubtless showed great skill in so managing his account, as to take off the main force of the accusation, and by that means make way for his pardon, which he accordingly obtained.

CHAP. III. Of the Proposition.

IN every just and regular discourse, the speaker's intention is to prove or illustrate something. And when he lays down the subject upon which he designs to treat, in a distinct and express manner, this is called the *proposition*.

Orators use several ways in laying down the subject of their discourses. Sometimes they do it in one general proposition. We have an instance of this in Cicero's speech to the senate, the day after Cæsar was killed (as it is given us by Dion Cassius), in which his design was to persuade them to peace and unanimity. "This (says he) being the state of our affairs, I think it necessary that we lay aside all the discord and enmity which have been among us, and return again to our former peace and agreement." And then he proceeds to offer his reasons for this advice.

At other times, to give a clearer and more distinct view of their discourse, they subjoin to the proposition

Disposition. the general heads of argument by which they endeavour to support it. This method Cicero uses in his seventh Philippic, where he says, "I who have always commended and advised to peace, am against a peace with Mark Antony. But why am I averse to peace? Because it is base, because it is dangerous, and because it is impracticable. And I beseech you to hear me with your usual candour, while I make out these three things."

29 When the subject refers to several different things, and requires to be laid down in distinct propositions, it is called a *partition*.

But when the subject relates to several different things, which require each of them to be separately laid down in distinct propositions, it is called a *partition*; though some have made two kinds of *partition*, one of which they call *separation*, and the other *enumeration*. By the former of these, the orator shows in what he agrees with his adversary, and wherein he differs from him. So, in the case formerly mentioned, of a person accused of sacrilege for stealing private money out of a temple, he who pleads for the defendant says, "He owns the fact; but it being private money, the point in question is, Whether this be sacrilege?" And in the cause of Milo, Cicero speaking of Clodius, says, "The point which now comes before the court, is not, Whether he was killed or not; that we confess: but, Whether justly or unjustly." Now in reality here is no partition, since the former branch of the proposition is what is agreed upon, and given up; and consequently it is only the latter that remains to be disputed. It is called *enumeration*, when the orator acquaints his hearers with the several parts of his discourse upon which he designs to treat. And this alone, properly speaking, is a *partition*. Thus Cicero states his plea in his defence of Muræna: "I perceive the accusation consists of three parts: the first respects the conduct of his life; the second his dignity; and the third contains a charge of bribery."

There are three things requisite in a good partition; that it be *short*, *complete*, and consist but of a *few members*.

A partition is said to be *short*, when each proposition contains in it nothing more than what is necessary. So that the brevity here required is different from that of a narration; for that consists chiefly in things, this in words. And, as Quintilian justly observes, brevity seems very proper here, where the orator does not show what he is then speaking of, but what he designs to discourse upon.

Again, it ought to be *complete* and perfect. And for this end, care must be taken to omit no necessary part in the enumeration.

But, however, there should be as *few heads* as is consistent with the nature of the subject. The ancient rhetoricians prescribe three or four at the most. And we do not remember that Cicero ever exceeds that number. But it is certain, the fewer they are, the better, provided nothing necessary be omitted. For too large a number is both difficult of retention, and apt to introduce that confusion which partition is designed to prevent.

Hitherto we have been speaking only of those heads into which the subject or general argument of the discourse is at first divided. For it is sometimes convenient to divide these again, or at least some of them, into several parts or members. And when this happens, it is best done, as the speaker comes to each of

them in the order at first laid down; by which means the memory of the hearers will be less burdened than by a multitude of particulars at one and the same time. Thus Cicero, in his oration for the Manilian law, comprises what he designs to say under three general heads. "First (says he) I shall speak of the nature of the war, then of its greatness, and lastly about the choice of a general." And when he comes to the first of these, he divides it again into four branches; and shows, "how much the glory of the Romans, the safety of their allies, their greatest revenues, and the fortunes of many of their citizens, were all concerned in that war." The second head, in which he considers the greatness of the war, has no division. But when he comes to the third head, concerning the choice of a general, he divides that likewise into four parts; and shows, that so many virtues are necessary in a consummate general, such an one as was proper to have the management of that war, namely, *skill in military affairs, courage, authority, and success*: all which he attributes to Pompey. And this is the scheme of that celebrated oration.

This subdividing, however, should never have place but when it is absolutely necessary. To split a subject into a great many minute parts, by divisions and subdivisions without end, has always a bad effect in speaking. It may be proper in a logical treatise; but it makes an oration appear hard and dry, and unnecessarily fatigues the memory. In a sermon, there may be from three to five, or six heads, including subdivisions; seldom should there be more.

Further, some divide their subject into two parts, ³⁰ *Negative* and propose to treat upon it *negatively* and *positively*; and by showing first what it is not, and then what it is. But while they are employed to prove what it is not, they are not properly treating upon that, but something else; which seems as irregular as it is unnecessary. For he who proves what a thing is, does at the same time show what it is not. However, in fact, there is a sort of division by affirmation and negation, which may sometimes be conveniently used. As if a person, charged with killing another, should thus state his defence: *I had done right if I had killed him, but I did not kill him*. Here indeed, if the latter can be plainly made to appear, it may seem needless to insist upon the former. But if that cannot be so fully proved, but there may be room left for suspicion, it may be proper to make use of both: for all persons do not see things in the same light, and he who believes the fact, may likewise think it just; while he who thinks it unjust, may not believe it, but rather suppose, had it really been committed by the party, he would not have denied it, since he looked upon it as defensible. And this method of proceeding, Quintilian compares to a custom often used in traffic, when persons make a large demand at first, in order to gain a reasonable price. Cicero uses this way of reasoning in his defence of Milo; but in the contrary order: that is, he first answers the charge; and then justifies the fact, upon the supposition that the charge was true. For he proves, first, that Clodius was the aggressor; and not Milo, as the contrary party had asserted: and then to give the greater advantage to his cause, he proceeds to show, that if Milo had been the aggressor, it would however have been a glorious action.

Disposition tion to take off such an abandoned wretch, who was not only a common enemy to mankind, but had likewise often threatened his life.

A good and just partition is attended with considerable advantages. For it gives both light and ornament to a discourse. And it is also a great relief to the hearers, who, by means of these stops and rests, are much better enabled to keep pace with the speaker without confusion, and by casting their thoughts either way, from what has been said, both know and are prepared for what is to follow. And as persons, in travelling a road with which they are acquainted, go on with greater pleasure and less fatigue, because they know how far it is to their journey's end; so to be apprised of the speaker's design, and the several parts of his discourse which he proposes to treat on, contributes very much to relieve the hearer, and keep up his attention. This must appear very evident to all who consider how difficult it is to attend long and closely to one thing, especially when we do not know how long it may be before we are like to be released. Whereas, when we are before-hand acquainted with the scheme, and the speaker proceeds regularly from one thing to another, opportunity is given to ease the mind, by relaxing the attention, and recalling it again when necessary. In a sermon, or in a pleading at the bar, few things are of greater consequence than a proper or happy division. It should be studied with much accuracy and care; for if one take a wrong method at first setting out, it will lead them astray in all that follows. It will render the whole discourse either perplexed or languid; and though the hearers may not be able to tell where the fault or disorder lies, they will be sensible there is a disorder somewhere, and find themselves little affected by what is spoken. The French writers of sermons study neatness and elegance in the division of their subjects much more than the English do; whose distributions, though sensible and just, yet are often inartificial and verbose.

CHAP. IV. Of Confirmation.

³¹ Confirmation is used for the arguments brought in defence of a subject.

THE orator having acquainted his hearers, in the proposition, with the subject on which he designs to discourse, usually proceeds either to prove or illustrate what he has there laid down. For some discourses require nothing more than an enlargement or illustration, to set them in a proper light, and recommend them to the hearers; for which reason, likewise, they have often no distinct proposition. But where arguments are brought in defence of the subject, this is properly *confirmation*. For, as Cicero defines it, "confirmation is that which gives proof, authority, and support to a cause, by reasoning." And for this end, if any thing in the proposition seems obscure, or liable to be misunderstood, the orator first takes care to explain it, and then goes on to offer such arguments for the proof of it, and represent them in such a light, as may be most proper to gain the assent of his hearers.

But here it is proper to observe, that there are different ways of reasoning suited to different arts. The mathematician treats his subject after another manner than the logician, and the orator in a manner

different from them both. Two methods of reasoning are employed by orators, the *synthetic* and *analytic*.

I. Every piece of synthetic reasoning may be resolved into a syllogism or series of syllogisms, (see Logic.) Thus we may reduce Cicero's argument, by which he endeavours to prove that Clodius assaulted Milo, and not Milo Clodius, to a syllogism in this manner:

³² Synthetic reasoning may always be resolved into a syllogism or series of syllogisms.

He was the aggressor, whose advantage it was to kill the other.

But it was the advantage of Clodius to kill Milo, and not Milo to kill him.

Therefore Clodius was the aggressor, or he assaulted Milo.

The thing to be proved was, that Clodius assaulted Milo, which therefore comes in the conclusion: and the argument, by which it is proved, is taken from the head of profit or advantage. Thus the logician would treat this argument; and if either of the premises were questioned, he would support it with another syllogism. But this short and dry way of reasoning does not at all suit the orator: who not only for variety changes the order of the parts, beginning sometimes with the minor, and at other times with the conclusion, and ending with the major; but likewise clothes each part with such ornaments of expression as are proper to enliven the subject, and render it more agreeable and entertaining. And he frequently subjoins, either to the major proposition, or minor, and sometimes to both, one or more arguments to support them; and perhaps others to confirm or illustrate them as he thinks it requisite. Therefore, as a logical syllogism consists of three parts or propositions, a rhetorical syllogism frequently contains four, and many times five parts. And Cicero reckons this last the most complete. But all that is said in confirmation of either of the premises is accounted but as one part. This will appear more evident by examples. By a short syllogism Cicero thus proves, that the Carthaginians were not to be trusted: "Those who have often deceived us, by violating their engagements, ought not to be trusted. For if we receive any damage by their treachery, we can blame nobody but ourselves. But the Carthaginians have often so deceived us. Therefore it is madness to trust them." Here the major proposition is supported by a reason. The minor needed none; because the treachery of the Carthaginians was well known. So that this syllogism consists of four parts. But by a syllogism of five parts he proves somewhat more largely and elegantly, that the world is under the direction of a wise governor. The major is this: "Those things are better governed which are under the direction of wisdom, than those which are not." This he proves by several instances: "A house managed with prudence has every thing in better order, and more convenient, than that which is under no regulation. An army commanded by a wise and skilful general is in all respects better governed than one which has a fool or a madman at the head of it. And the like is to be said of a ship, which performs her course best under the direction of a skilful pilot." Then he proceeds to the minor thus: "But nothing is better governed than the universe." Which

Disposition. Which he proves in this manner: "The rising and setting of the heavenly bodies keep a certain determined order; and the several seasons of the year do not only necessarily return in the same manner, but are suited to the advantage of the whole; nor did the vicissitudes of night and day ever yet become prejudicial, by altering their course." From all which he concludes, "That the world must be under the direction of a wise governor." In both these examples, the regular order of the parts is observed. We shall therefore produce another, in which the order is directly contrary; for beginning with the conclusion, he proceeds next to the minor proposition, and so ends with the major. In his defence of Cælius, his design is to prove that Cælius had not led a loose and vicious life, with which his enemies had charged him. And this he does, by showing he had closely followed his studies, and was a good orator. This may probably at first sight appear but a weak argument; though to him who considers what Cicero everywhere declares necessary to gain that character, it may perhaps be thought otherwise. The sense of what he says here may be reduced to this syllogism.

Those who have pursued the study of oratory, so as to excel in it, cannot have led a loose and vicious life.

But Cælius has done this.

Therefore his enemies charge him wrongfully.

But let us hear Cicero himself. He begins with the conclusion, thus: "Cælius is not chargeable with profuseness, extravagancy, contracting of debts, or intemperance, a vice which age is so far from abating, that it rather increases it. Nay, he never engaged in amours, and those pleasures of youth, as they are called, which are soon thrown off, as reason prevails." Then he proceeds to the minor, and shows from the effects, that Cælius had closely applied himself to the best arts, by which he means those necessary for an orator: "You have now heard him make his own defence, and you formerly heard him engaged in a prosecution (I speak this to vindicate, not to applaud him), you could not but perceive his manner of speaking, his ability, his good sense, and command of language. Nor did he only discover a good genius, which will oftentimes do much of itself when it is not improved by industry; but what he said (if my affection for him did not bias my judgment) appeared to be the effect of learning, application, and study." And then he comes to the major: "But be assured, that those vices charged upon Cælius, and the studies upon which I am now discoursing, cannot meet in the same person. For it is not possible that a mind, disturbed by such irregular passions, should be able to go through what we orators do, I do not mean only in speaking, but even in thinking." And this he proves by an argument taken from the scarcity of good orators. "Can any other reason be imagined, why so few, both now, and at all times, have engaged in this province, when the rewards of eloquence are so magnificent, and it is attended with so great delight, applause, glory, and honour? All pleasures must be neglected; diversions, recreations, and entertainments omitted; and even the conversation of all our friends must in a manner be laid aside. This it is which de-

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ters persons from the labour and study of oratory; not their want of genius or education."

2. By *Enthymem*. But orators do not often use complete syllogisms, but most commonly enthymems. An *enthymem*, as is shown elsewhere, is an imperfect syllogism, consisting of two parts; the conclusion, and one of the premises. And in this kind of syllogism, that proposition is omitted, whether it be the major or minor, which is sufficiently manifest of itself, and may easily be supplied by the hearers. But the proposition that is expressed is usually called the *antecedent*, and the conclusion the *consequent*. So if the major of that syllogism be omitted, by which Cicero endeavours to prove that Clodius assaulted Milo, it will make this enthymem:

The death of Milo would have been an advantage to Clodius.

Therefore Clodius was the aggressor; or, therefore he assaulted Milo.

In like manner that other syllogism above-mentioned, by which he shows that the Carthaginians ought not to be trusted, by omitting the minor, may be reduced to the following enthymem:

Those who have often broke their faith ought not to be trusted.

For which reason the Carthaginians ought not to be trusted.

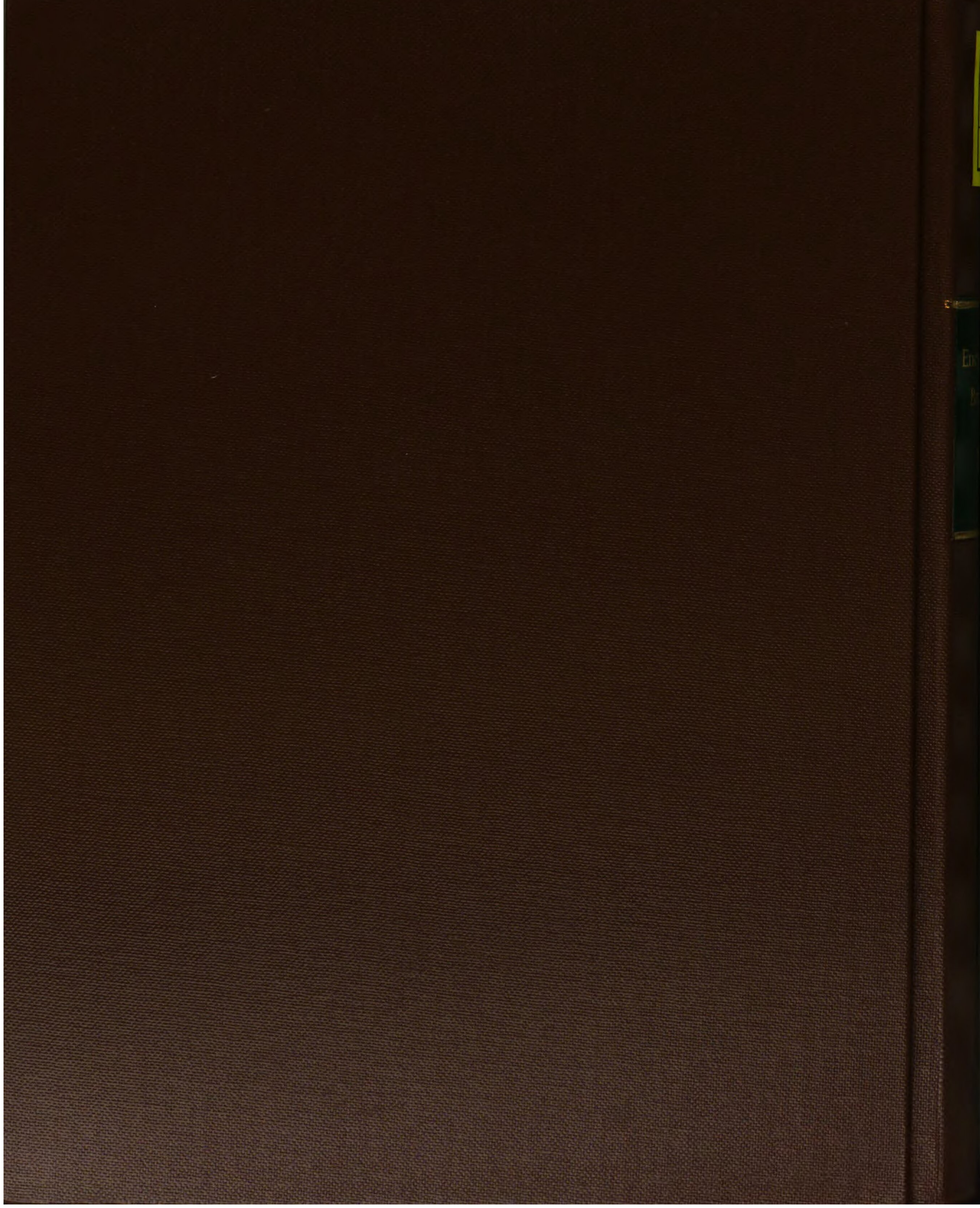
Every one would readily supply the minor, since the perfidiousness of the Carthaginians was known to a proverb. But it is reckoned a beauty in enthymems, when they consist of contrary parts: because the turn of them is most acute and pungent. Such is that of Micipsa in Sallust: "What stranger will be faithful to you who are an enemy to your friends?" And so likewise that of Cicero for Milo, speaking of Clodius: "You sit as avengers of his death; whose life you would not restore, did you think it in your power." Orators manage enthymems in the same manner they do syllogisms; that is, they invert the order of the parts, and confirm the proposition by one or more reasons: and therefore a rhetorical enthymem frequently consists of three parts, as a syllogism does of five. Though, strictly speaking, a syllogism can consist of no more than three parts, and an enthymem but of two: and the arguments brought to support either of the propositions constitute so many new enthymems, of which the part they are designed to prove is the conclusion. To illustrate this by an example:

An honest man thinks himself under the highest obligation to his country.

Therefore he should shun no danger to serve it.

In this *enthymem* the major is wanting, which would run thus: "He who is under the highest obligations to another, should shun no danger in order to serve him." This last proposition is founded upon the common principle of gratitude; which requires that, to the utmost of our power, a return should be made in proportion to the kindness received. And this being a maxim generally allowed, it is omitted by the orator. But now this enthymem, consisting of the minor and conclusion, might be managed in some such manner

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Bd.: 13,1

Edinburgh (1810)

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